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APRIL/MAY 1992

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WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

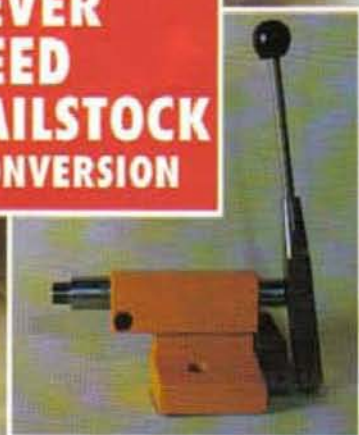
ER'S Workshop w

**HORIZONTAL
CLAMPS**

**CHUCK
BACKSTOPS**



**LEVER
FEED
TAILSTOCK
CONVERSION**



**EASY
PACKINGS**



**MILLING
FOR
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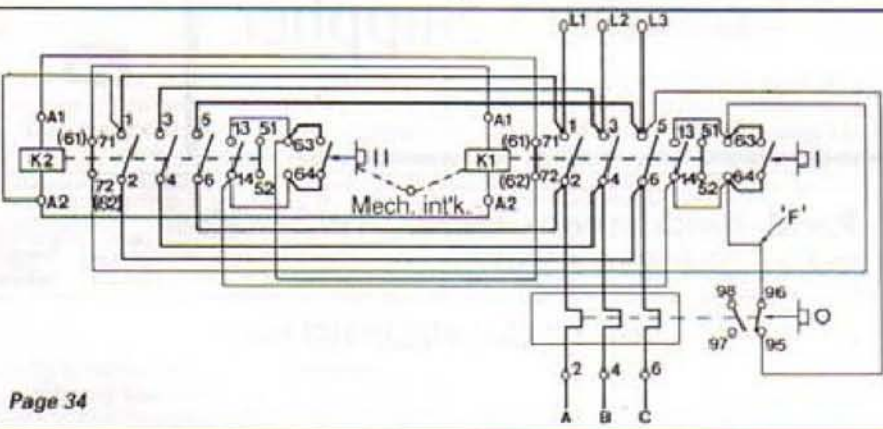
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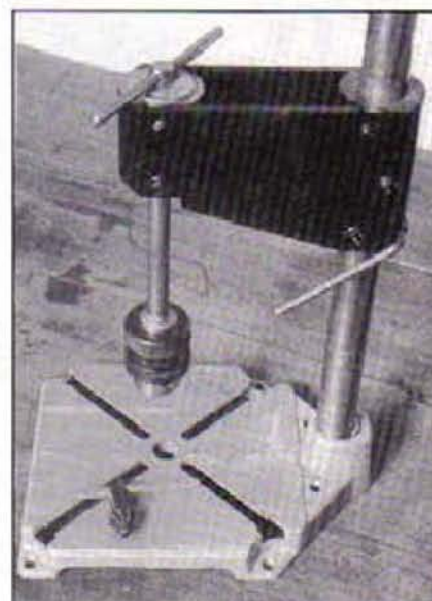
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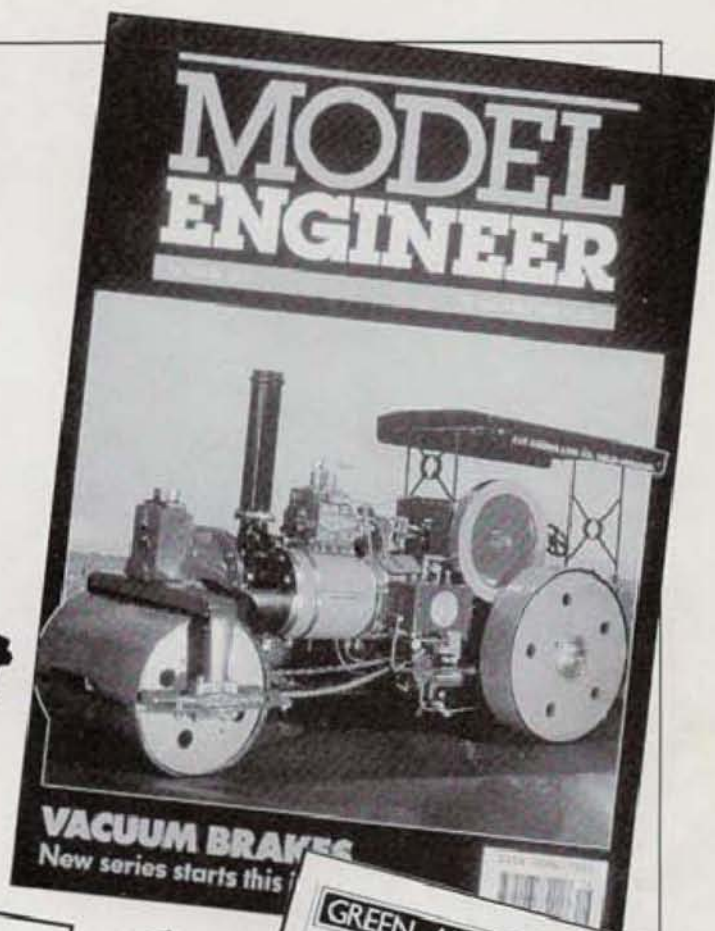
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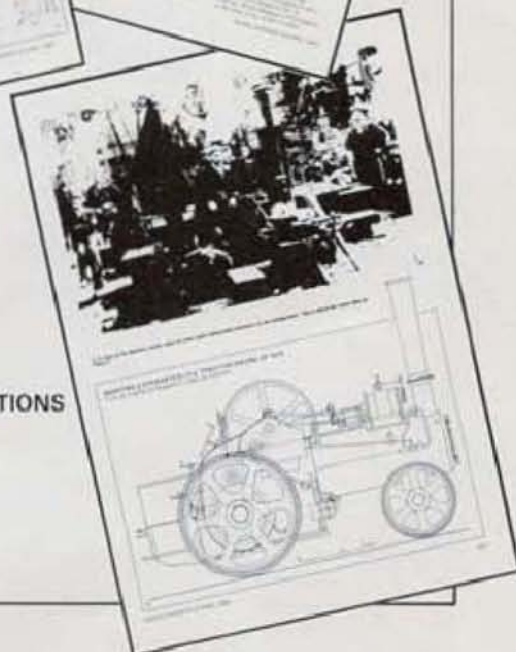
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TO LOOK
FORWARD
TO...**
...every fortnight



There's something to anticipate twice every month in fascinating Model Engineer magazine! Whether your interests lie in live steam locomotive models, traction engines, internal combustion motors or stationary engines, world famous M.E. will inspire, instruct, advise and encourage. Model Engineer is published on the first and third Fridays each month and costs just £1.40 from all good newsagents; alternatively, you may care to ensure your regular copies through an annual subscription – a mere £33.60 for UK readers (overseas rates and airmail details on request).

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Harold Hall

ON THE EDITOR'S BENCH

The beginning of the year saw the International Model Engineer and Modelling Exhibition being held at Alexandra Palace, an event which I have attended irregularly for about 40 years, first going as a teenager to the Horticultural Halls in London. I have, though, attended almost without missing for around 15 years.

Even so this exhibition was quite a new experience for me, attending as editor of *Model Engineers' Workshop*. I was able to meet many readers of this magazine, some by arrangement and many who made themselves known for the first time. This was a very pleasant experience meeting people face to face and discussing matters relating to *MEW*. Even those readers who wished to comment on some aspect of the magazine with which they were not happy were, almost without exception, complimentary regarding *Model Engineers' Workshop*. This was very satisfying!

My one regret was that, due to pressures to keep this issue of the magazine on schedule, I was unable to attend as often as I would have liked. The result of this was that many who asked if I was available were unable to make contact with me and for this I can only apologise. Perhaps by the next exhibition I will be on top of this task and will be able to attend on more occasions.

Whilst on the subject of exhibitions, readers may like to know that the International Exhibition of Machine Tools and Manufacturing Technology, MACH92, is to be held at the National Exhibition Centre Birmingham. This will be from the 6th May to the 15th May. Those who can justify their attendance on the basis of their daily employment, can obtain advance tickets by phoning 071 723 8891.

Also of interest to some readers will be the one day seminar, organised by The Society of Model and Experimental Engineers, to be held on 4th April at the Holiday Inn, Sutton, Surrey. For an application form to attend, send a stamped addressed envelope to A J Hawtin SMEE (seminar) PO Box 192, Carshalton, Surrey SM5 3TQ. There will also be trade exhibitors in attendance.

Since the last issue there has been a very noticeable increase in correspondence received; whether this is coincidental or due to the content of the previous magazine, or perhaps a growing interest in *MEW*, only time will tell. Three items published have particularly generated comment.

I had published in 'Scribe a Line' Dec/Jan a letter from Mr Gunston regarding his rather old drill chuck; this I considered was an interesting item but felt

it unlikely to generate any replies. How wrong could I be! About ten replies were received, far more than had been received on a single subject before.

Whilst these letters did not solve Mr Gunston's problem, they did indicate that this type of chuck had been made by many manufacturers from the early part of the century, quite a few readers still having early catalogues to prove this. Thanks to all those who replied, and sorry I cannot publish all your letters.

Another article with a similar number of replies was *Keeping Rust At Bay*. This subject is of such importance that I have considered it a good idea to publish most of them as a separate feature in this issue.

The article with by far the greatest number of letters received so far, has been that relating to the Digital Readout. Some were requesting the additional diagram offered in the article, another (published in the last issue) confirmed the suggestion of a flag for reversal indication was viable – the reader had already come up with the same idea on his own design.

A number of readers have made observations regarding small improvements. Others have written to explain they were in the process of finalising their own design and had found the article useful; others just found it interesting with no real intention of ever making the item.

I did like the very unselfish attitude of Mr P Blampied of C. Fermanagh who said, "The digital feature is boring to me, but it is good to see that such a specialist feature is published. Good solid in-depth information like this article must be a winner."

Unfortunately two readers did find that publishing such an article was totally unacceptable; I feel they did not appreciate that some home machinists would get the satisfaction of making such a device, in much the same way as a model engineer would when making some very demanding engineering model. It is no doubt true to say that, in most cases, it will not repay the time spent in the unit.

Despite the large volume of letters, may I say if you wish to write on any subject, criticism or praise, comment or query, please do write.

At the risk of boring you, I would like to briefly mention the need for articles once again. A reader has indicated that some potential authors may be put off sending in articles, thinking that they had to be complete and ready for insertion in the magazine, especially the drawings. This is not so. Drawings are almost always redrawn, and if photographs cannot be obtained then it may be possible to send a

photographer to take these for the article. It is also possible that, in some cases for simple ideas, I can construct the item and photograph it myself.

These comments are particularly relevant as it is now becoming the simpler items (say up to four magazine pages) which are in short supply. Any reader interested can send for a copy of our guide notes for authors. So if you have made some device perhaps a one or two evening project, do not write this off as something we would not be interested in. It is probably just what is required!

Comments from a number of readers, including the questionnaire, show a desire for some assistance with mathematics as applicable to workshop activities. An article has been prepared and is included in this issue. If any readers still wish to start at an earlier level – say algebra – I will endeavour to produce a few pages on the subject, from which I will make photocopies available. I do hope this article will prove beneficial and will be pleased to receive your comment on its inclusion.

The last issue included a lathe mounted band saw; this included the full text but only half of the required drawings. The remaining drawings are included in this issue, again being the subject of the centre fold.

I have been made aware by two readers of an error on page 38 relating to this article in which it states a band speed of 0.250 ft. per min. – far too slow. Unfortunately at the time I had no copying machine, and the author's original notes had to be sent to the publishers. I therefore have nothing to check this against. However, it is logical to consider that it should be 250 ft. per min., which in fact calculates to around 220 ft. per min.

It is worth considering that for those who would prefer a free standing band saw, the design could very easily be adapted to include bench mounting facilities and to be driven from its own self-contained motor.

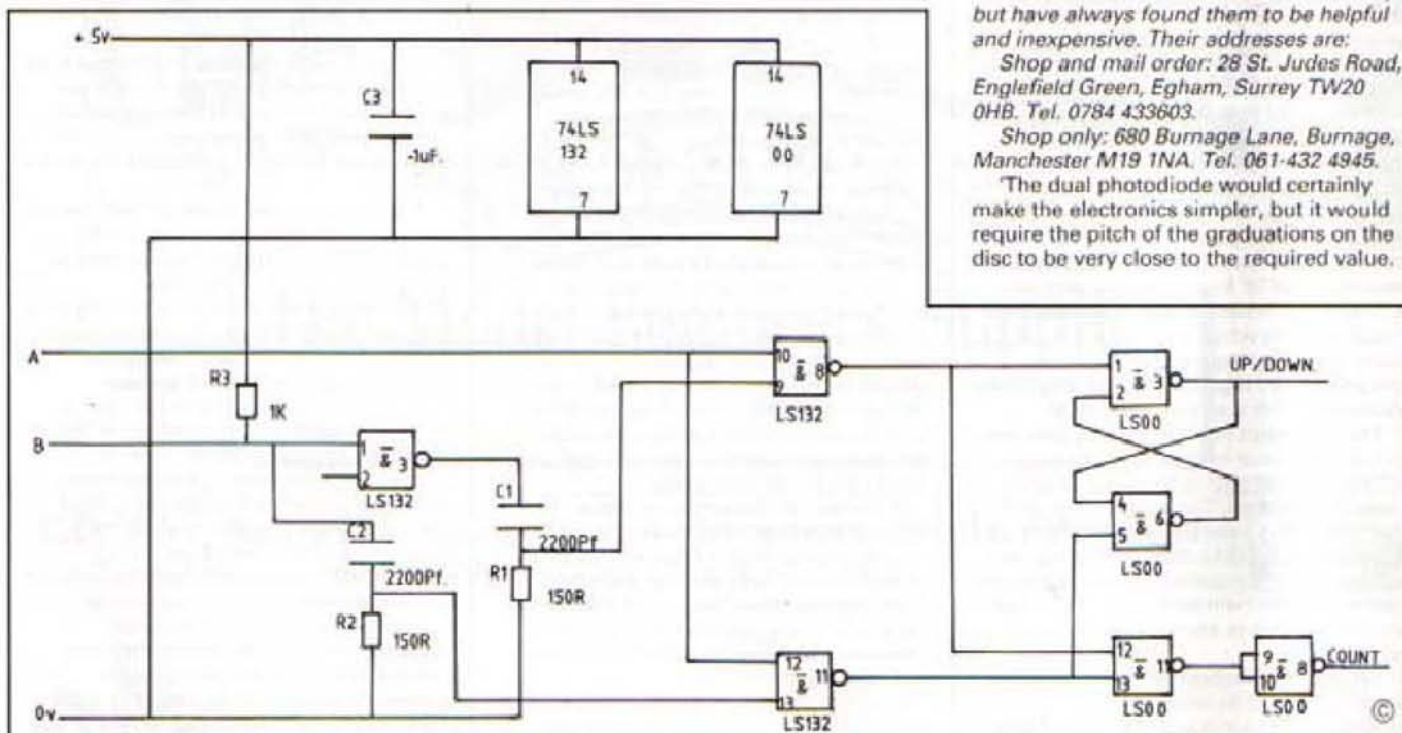
I have received a letter from an Australian reader who wishes to make contact with Mr Frank Birchall who supplied the 'Quick Tip' published in the Aug/Sept. issue. Unfortunately as this was only a quick tip, correspondence was not kept and his address is not available at the office. If Mr Birchall (or a friend of his) reads this, would you please contact me so that I can forward the details to you.

The reader survey highlighted a desire on the part of a large number of readers for articles with the beginner in mind. To help meet this requirement a series has been written relating to the milling machine and its use. This will be a four-part series starting in this issue with the machine and workholding. It will be followed by cutters and cutter holding, then some discussion on the actual milling operations. The series will conclude with the special considerations of milling in the lathe.

The request for articles on specific subjects last issue produced mixed results, with some items resulting in more than one offer and others with none. I will conclude with just one request in this issue. A constructional article for a vertical slide for milling on the lathe is required. This ideally should be made from stock materials, but one made from castings would also be useful. Please contact me first with details of your offer.

SCRIBE A LINE

Your views, your pages! Your opportunity to make your point, ask the question or simply pass on a snippet of interesting advice to others. Your letters for publication in Model Engineers' Workshop are always welcome



Digital readouts

Mr Lee of Bourne End, Bucks makes some observation re the Digital Readout design.

I was very interested in the digital readout featured in the December/January edition, as my Archdale has 5 T.P.I. leadscrews on the X and Y axes, and 10 T.P.I. on the Z axis. Y and Z are calibrated in thous. while X is in ten thou. divisions with a vernier scale. This can get very complicated!

However, I would like to make some comments on the pulse shaping and direction sensing circuit.

The ordinary 7400 series TTL logic is rather out of date. The LS series is cheaper, more readily available, and uses less power. It is also faster, though that is not a consideration here.

This circuit can be implemented with two chips, one 74LS132 and one 74LS00. The trailing edge CR network (C2R2) can be fed from the B input, saving one gate. On the accompanying drawing, I have shown a 1K pull-up resistor (R3), in case the sensor cannot source enough current for this

purpose, but I would imagine this to be unnecessary.

The two gates following the CR networks are the only gates which are subjected to slowly changing input signals. These should really have Schmitt inputs. The open collector gates are not required for single-edge counting, so I have drawn the '132 in this position, omitting the collector load resistors R3 and R4, and using one of its gates as the inverter.

The cross-couple and the count output gate do not need Schmitt inputs now, as the previous gates cannot remain in the unstable state. I have therefore drawn a 74LS00 here. I have no data sheet for the ZN1040E but I understand it to be TTL compatible, so I have left out the pull-up resistors R5 and R6.

With the original circuit, a change of direction from count-down to count-up will produce the count pulse rising edge and the direction signal simultaneously. On a change from count-up to count-down, the count pulse leading edge occurs one gate delay before the direction signal changes. I do not have a timing diagram for the

ZN1040E, but I would have thought that these conditions could give rise to lost or incorrect counts. (This was covered in Part two of the article. In fact 1 count is made in the wrong direction on each reversal. As all readings have to be taken going to same way these cancel out. Ed.) Using the spare gate of the 'LS00 as an inverter, thereby using the end of the count pulse as the counting edge, will ensure that this situation cannot arise.

As an option, the remaining gate of the 'LS132 could be used to light an L.E.D. when the B input is high, to indicate count + half a thou.

It was always said at work, that the day you finally got your plate of chips working, some manufacturer would announce a chip which made it obsolete. The Electrovalue catalogue quotes a sensor with "dual photodiodes and appropriate logic to provide count and direction outputs". This is priced at £4.69 + VAT.

I have no connection with Electrovalue, but have always found them to be helpful and inexpensive. Their addresses are:

Shop and mail order: 28 St. Judes Road, Englefield Green, Egham, Surrey TW20 0HB. Tel. 0784 433603.

Shop only: 680 Burnage Lane, Burnage, Manchester M19 1NA. Tel. 061-432 4945.

The dual photodiode would certainly make the electronics simpler, but it would require the pitch of the graduations on the disc to be very close to the required value.

The reason for this being the only method of adjustment to achieve the ¼ cycle displacement would be to move the device toward or away from the disc centre.

The variation only being that due to the graduations becoming further apart, towards the edge of the disc. Ed.'

Long term models and hams

Mr R P Neave of Manningtree is claiming a record; he also writes about his interest as a radio amateur. Do we have any like-minded reader who could make contact with him I wonder?

I am now nearly 74 but still very active; my background is agricultural engineering and model making is only one of my activities. I have recently completed a Stuart 10H, the castings of which I first purchased in 1937 for 8s. 6d. and on which very little work other than filling was done until Sept. 1990. I suppose this might be some form of inverted record!

I have owned four lathes, all since World War Two. A 4 in. treadle type of no name, but very similar to an early Britannia, and

which I motorised. This was followed by a 3 5/8 in. Portass, then by a 4 1/2 in. x 18 in. Boxford which has just been replaced by a Boxford BUD 4 1/2 in. x 22 in. bed with a Norton gearbox. Also I have a very old vertical milling machine of unknown make.

Digressing slightly, I was a member of the Norwich and D S M E for a short while; I remember at one of their exhibitions seeing a beam engine in which the beams were vertical and the cylinders were square in section and curved like the section of a wooden cartwheel. It was, I think, a two-cylinder model.

It was such an unusual design yet I have never seen or heard mention of it since 1936, perhaps a mention in MEW will bring it to light ...

Another hobby on an equal level with engineering is Amateur Radio (callsign is G4 DAN) hence a great interest in the various articles on the digital control and workshop electronics generally.

Wiring safety

Mr P. Ray of the City and East London College refers to the Workshop Wander article in the Aug/Sept 1991 issue. See my postscript at the end of the letter.

I have just discovered your excellent magazine which has given a number of us lecturers at this college some ideas to set up a model engineers class.

The reason for this letter is to put right some very bad electrical practice shown in the 'Workshop Wander' article, with respect to public safety. I realize that the Health and Safety at work act does not apply at home. However your magazine does owe a duty of care to its readership, so therefore please consider publishing this letter.

I refer to photograph numbers in the article. All wiring regulations are contained in the 16th edition of the Institute of Electrical Engineers Wiring Regulations.

5. No eye shields being worn, bad grip on drill, drill air vents blocked by the hand.

12. Cable badly clipped, run on skirting boards, twin and earth not strong enough for workshop use. Steel/high impact 20mm conduit and fittings should have been used, or steel wire armoured cable and better sited.

14. Socket outlet adaptors should not be used, especially where mechanical work areas are concerned - more outlets required. Note the extra adaptor sitting under the socket waiting to be used. Lots of items cluttering socket access, would have been better to fit in, and others, on the front of the bench.

16. Electrical tools hung up by their cords - bad practice.

17. What are these 240v cables floating around for?

18. Very nasty this one! No nippy vice on the drill, exposed beltwork, flexible cord on motor should be armour flex as it is a fixed machine, socket behind machine making emergency disconnection tricky, no earth cross bonding between motor and drill, rubber blanking grommet (20mm) in top of switch socket outlet not suitable for workshop use, 20mm steel plug and lock ring should be used, socket clearly only fixed on centre rather than be socket outlet corners.

Well, that's the criticism done (to help)! If your magazine ever wants advice I would always help.

Postscript - from the Editor

Mr Ray sets a very high standard, as one would expect, and hope for, from a lecturer in Electrical Installations. His advice to use steel or high impact conduit or even steel wired armoured is I feel one which very few readers will be able to comply with.

The regulations state:

522-06 IMPACT

522-06-01 A wiring system shall be selected and erected so as to minimise mechanical damage.

522-06-02 In a fixed installation where an impact of medium severity (AG2) or high impact severity (AG3) can occur, protection shall be afforded by:

(i) the mechanical characteristics of the wiring system, or

(ii) the location selected, or

(iii) the provision of additional local or general mechanical protection, or by any combination of the above.

AG2 and AG3 are still to be defined by the International Electrotechnical Commission (IEC).

The reasonable approach would appear to be:

1. Locate cables in the safest possible position.

2. Protect locally in areas of possible damage.

3 phase electrics

Mr Riley of Tiverton comments about the Three Phase article in the Feb/Mar 1992 issue

When using switch fuses, do ensure that the supply connections are connected to the switch and the load to the fuses. This ensures that, when the switch is off and the handle interlock permits the door to open, the fuses will not be alive which would be the case if connected the other way round.

Normal domestic type junction boxes are not rated to withstand 415V. Do use suitably rated industrial boxes, if it is required to interconnect cabling.

Clear lacquer and calorific values

Mr Richards of Dudley offers a solution to Mr Eave's request in Scribe a Line Dec/Jan issue then poses his own rather special question.

With regard to Mr D Eave's request for clear lacquer, this can be obtained from DIY motor spares shops in spray can or pencil type touch up sticks, or a good horological supplies emporium.

Now my problem as a newcomer to the engineering side of model making: is there a book giving the calorific values of fuels and their uses and method of storage? What I need is something which tells me if it is Venturi, wick or pressure feed. Insulated storage. Atmospheric or blown air combustion feed. The list seems endless now I've started. HELP!

Clinometers

Mr J R Tovill of Telford writes.

Referring to the letter of Mr Thompson on the Sine Bar Clinometer (MEW Feb/Mar '92). The clino was not a gun sight but formed part of the gun laying equipment the clino set the angle of elevation of the gun. The radial bar described in the article was in fact a sine bar (hence the name).

Clinometers (Field) were made before World War One and in large numbers in World War Two. Various Mk's were produced mainly to promote ease of

manufacture; it can be seen in page 61 Feb/Mar '91 issue, a Taylor and Hobson clino made in 1915. The bubble adjustment was discontinued on latter Mk's.

The accuracy of the clino depends on the 0-45/45-90 degree faces being at exactly 90 degrees and the quadrant and pivot being on the 45 degree line. Although the two faces can be scraped to 90 degrees, the quadrant is difficult to align.

Clinos after the war were returned to army depots, the better ones sent for repair and checking. The residue were disposed of to the trade. A good clino is a very useful instrument.

Mr Thompson can check his clino with his existing set-up as I read it:

1. Check the two faces are at 90 degrees to each other using set square and surface plate.

2. If correct, set clino to read 45 degrees, place on mandrel face bring bubble level. Change face. Any error is in the quadrant, possibly a distorted frame.

Mr Thompson's other clino sounds like an Inspector's Clino that should be used in connection with a calibration chart. Hoping this is of some interest to readers.

Mr Whatmore of Tunbridge Wells writes.

The Sine Bar Clinometer was used by the master gunner during proof of the new fieldguns, to set up the gun and zero the sights, which were the normal method of aiming the gun.

All large gun barrels have a flat machined near the breach for the clino to rest on for this purpose (even back to Napoleonic days, but I believe they used a plumb bob and protractor then).

Odd drills

Can anyone identify the purpose of these drills, owned by Mr Sterland of Southwell, Notts?

In the Dec/Jan issue (No. 8), Mr Gunston wrote about a peculiar chuck. In my collection of useless things there are some large twist drills of uncertain age which have square tapered shanks and which fit no known chuck. The taper is about 1 in 12 and the maker's name on some is "Richard Carr and Company Ltd." Perhaps these fitted Mr Gunston's chuck. Apart from a wobbly fit in a carpenter's brace, the only use I have found is to saw off the shank, bore a hole and insert a Morse taper shank to use in a woodturning lathe.

Program improvements

Mr Leng has come up with an improvement to his computer program published in the Feb/Mar '92 issue.

I was pleased to receive your letter dated 30th Oct. confirming that you would publish my computer program in the Feb/Mar issue.

I have realised that although my program functions as written and draws wonderful patterns, the calculations in lines 330 and 340 are not absolutely correct, due to a slight misunderstanding from the programs in the Aug/Sept issue.

The original two part chuck program used a parameter called SR to represent the tool, position in the slide rest, and it was assumed that this could be replaced directly with dimension R5 in the composite program. Subsequent analysis, however, showed that R5 (or SR) should be

a radius from the centre of the output spindle. This can be achieved by inserting the following four lines between lines 400 and 410

```
402 AS =
R3*COS(U)+R4*COS((1+V3)*U+P2)
404 BS =
R3*SIN(U)+R4*SIN((1+V3)*U+P2)
406 R6 = SQR(AS↑2+BS↑2)
408 R5 = R5-R6
```

AS and BS are the X and Y coordinates of the output spindle axis.

R6 is the distance of the output spindle from the main axis.

In line 408, the new value of R5 is found by subtracting R6 from the old value.

Cross hole drilling

The Rev. R S Hatfull of Hyde Lea, Stafford adds to the long list of ideas on cross drilling.

Further to the contribution by Mr Harries in issue No. 9, may I suggest that there is yet another method – a very simple method that I have used for a number of years and which requires no jig?

All that need be done is to grip a short piece of bar, of the same diameter as that which is to be drilled, in the chuck of the drilling machine.

Then set the drill-vice until the fixed jaw just touches the bar and then clamp the vice to the drilling table.

The bar to be drilled is then set in the vice and the piece of bar in the chuck replaced by a centre drill – which latter is used to start the hole in the bar.

Replace the centre drill by the drill that is required, using a stub length drill if necessary, and drill the hole.

If the diameter of the bar to be cross-drilled is greater than the capacity of the chuck, simply turn down a short length of a piece of the same bar at one end until it will enter the chuck, and proceed as before.

Gears and gearcutting

Mr Martin of Sliema Malta raises a question which appears to have caused a number of readers to ask for clarification on the same subject, to which Don Unwin gives his reply.

With reference to the recent articles on gears and gear cutting, I decided to "have a go" but soon became confused.

I have the articles in MEW and also the Ivan Law book Gears and Gear Cutting. Referring to the tables given I note that for the 30 degree pressure angle cutters, the figures are identical except for the "feed in" figures which are obviously because of the different datum points.

In the table for the 20 degree pressure angle cutters, the sizes given for the pin diameter and pin centres are completely at odds. I would be obliged if you could tell me which is correct, before I cut up too much expensive silver steel.

I would just like to say thanks for the excellent magazine, especially the articles on tools and accessories, like the one in question.

Don Unwin replies

A copy of your letter has just been sent to me from MEW.

This query has been raised before by several correspondents after both the original articles published in Model Engineer in 1971 and the more recent

Mystery chuck

Regarding the origins of Mr Gunston's chuck (MEW issue 8, page 8).

The enclosed photocopy of a page from a Tyzack catalogue of about 1930 may be of interest. When I was at school at that time our school workshop had a drilling machine fitted with such a chuck, but I've not seen one since. Maybe nobody makes them any more – which is a pity as I've often thought it would make an excellent tailstock tap holder. Have any of your readers any ideas on making one? It could be a very interesting project.

Otherwise, I'm afraid I haven't any information about it.

This reply to Mr Gunston's question is one of about 10 replies received. May I take this opportunity of thanking all readers who replied to this. All letters have been passed to him. Ed.

version in MEW. The explanation is I think as follows:

The radius of a single curve involute tooth flank, that is the pin radius in the table, is given by Pin radius = pitch circle radius x sin pressure angle, see Gears for Small Mechanisms by W. O. Davis, 1953 pg. 72. If you apply the figures in the table you will see that I calculated the pin diameter for the lowest number of teeth in the cutter range and Mr. Law used the highest number. In the case of 30 deg. pressure angle I likewise used the lowest number and presumably so did Mr. Law.

The Browne & Sharpe circular arc involute gear form, originally devised in the mid 1800s, is a compromise which gives reasonable results with the minimum number of cutters to cover the complete range of teeth. To avoid tip interference the radius should be calculated smallest number of teeth in the range. This is illustrated if we look at cutter No. 1, 135 to rack. The basic rack has flanks with straight sides which if used for the 135 tooth gear would clearly give rise to tooth tip interference.

There are two errors in the tables as printed in Model Engineers Workshop.

Pg. 62, Table 1, column 4, line 1. Should be "5.6"

Pg. 63, Table 2, column 40, line b, should be "0.44" not 0.41.

I hope this answers your query.

Aids for the disabled

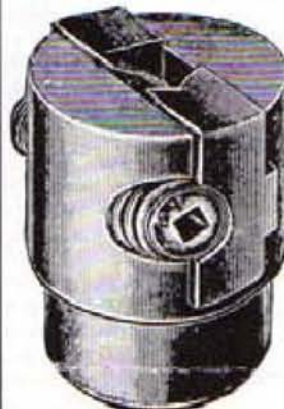
As a reader of a request from a disabled reader, I have developed an aid for removing heavy chucks from the lathe. This will be published in the next issue. It is so successful that I consider it will be of benefit to all readers when fitting and removing large chucks.

S. TYZACK & SON, LTD.

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With Ring
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No. TW1986	Take drills up to:	in.
6/9	7/9	9/16
15/6	22/6	38/16
No. TW1987	Take drills up to:	in.
7/9	8/6	10/16
17/16	24/16	42/16

Following this, the next letter has been received from another reader, Mr F W M Thomson of Ruislip. Any such ideas will always be considered for publication. Ed.

I am a disabled person having lost both hands and an eye in an accident at the age of 15 (I'm now 63) but I'm never happier than when I'm home from the office and making something from wood or metal, as was my father before me, and my son – a professional model-maker. It must be in our genes! Anyway I've done all the work on my workshop without help as a sort of personal challenge. Obviously I've a few gadgets and dodges to help me cope and I'm sure this must be true of other home engineers who have other forms of disablement. Would it be possible for a corner of MEW to be made available to tell about such gadgets for the encouragement of others? Most of them are very low tech, but then most good solutions are the simple ones.

Lathes

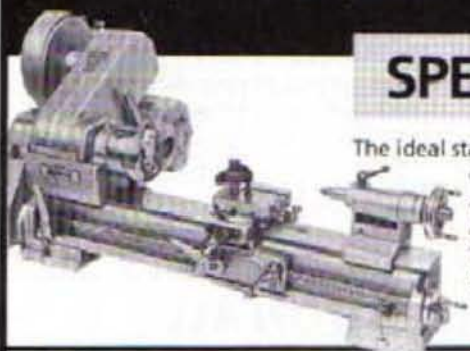
Borge Prytz of Klampenborg, Denmark has identified Mr Steve Sinclair's SR-80 lathe referred to in a recent Scribe a Line as of Danish origin, and has provided a lead to enable contact to be made with a company able to provide spares. Now here are two new queries both basically with the same problem relating to different lathes.

Mr J Nilson of Glasgow has an Excel plain lathe as shown by Mr Hadden Deering in his article on speed control in the Winter 1990/91 issue of MEW and who has been able to help to some extent. Still required is a source of supply of spares and can any reader loan Mr Nilson a copy of the lathe's manual or provide a photocopy?

Mr Eastment has an ML2; again, can any reader provide a copy of the lathe's manual

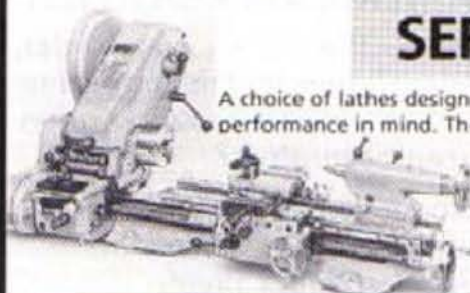
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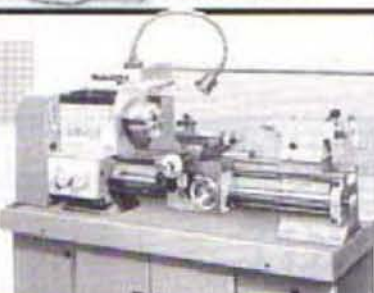


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In this demanding project, Don Unwin has updated his article, originally published in the *Model Engineer* in 1980, for an engraving attachment. It is intended to be fitted onto a milling machine, using the machine tables for positioning the part being engraved — a very useful idea. It would be simple to add its own work tables, for the reader who wished to have a self-contained machine.

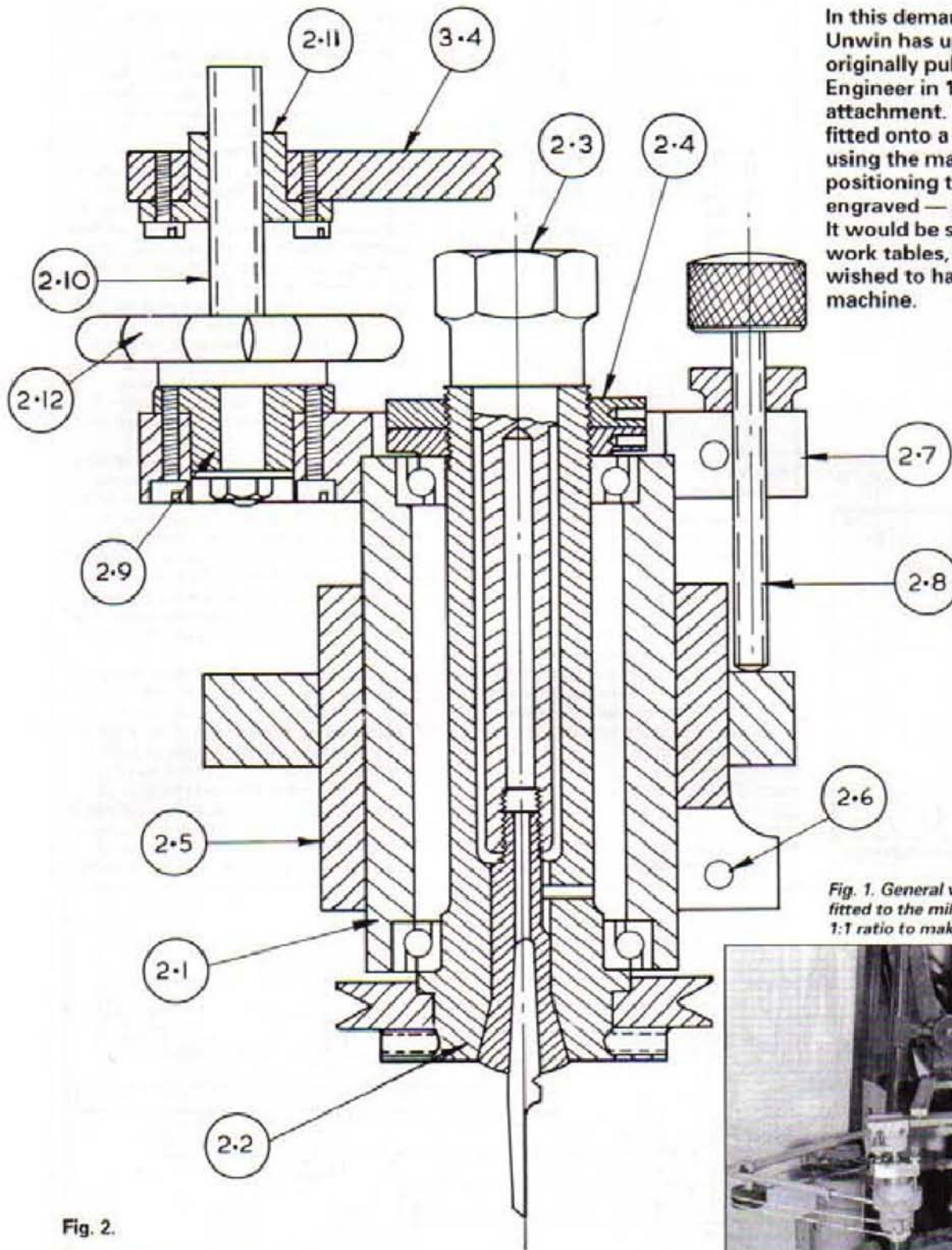
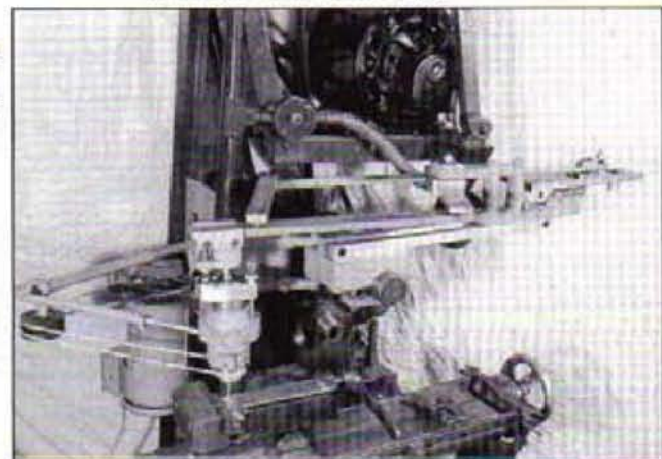


Fig. 2.
Section of cutter head assembly.

Fig. 1. General view of the attachment fitted to the milling machine and set up for 1:1 ratio to make master copy.



ENGRAVING ATTACHMENT

Figure and letter stamps can be used to make tolerably good characters. However they do have several limitations; the only size that can be used is that of the stamps available, special characters are difficult to make and the component being stamped must be capable of accepting the stamping blows without damage.

A much better and more versatile method of producing characters of professional quality is by means of a pantograph engraving machine. As my workshop was, and still is, very congested I designed and built an engraving attachment to fit on the overarm of my milling machine, using the machine traverses to provide the necessary movements required to position the workpiece.

Essentially the device consists of a high speed vertical milling spindle holding an endmill or engraving cutter which is caused to reproduce the shape of a master character by tracing around with a stylus or

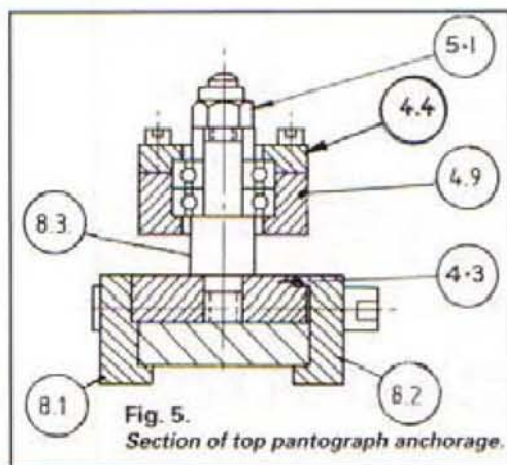


Fig. 5.
Section of top pantograph anchorage.

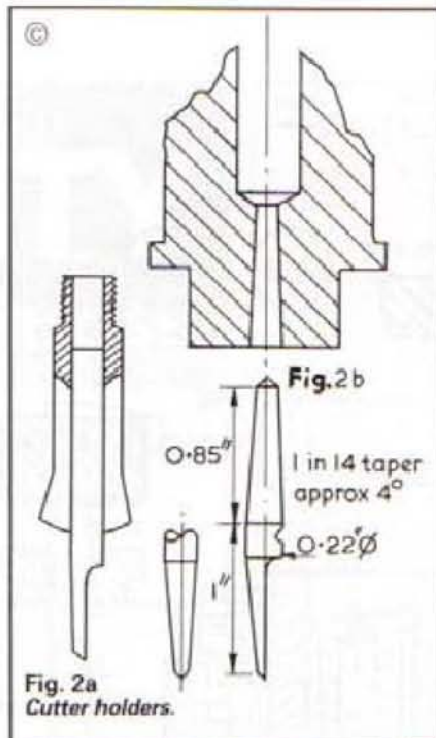


Fig. 2a
Cutter holders.

follower. The spindle has means of rapidly raising the cutter from the work and lowering it to a stop so that every character is reproduced to the same depth.

The motion of the tracing pin around the master character or 'copy' is transmitted to the cutting spindle by means of a pantograph with means of adjusting the reduction ratio to produce a range of sizes from a single size of master character.

To ensure accurate reproduction the pantograph needs to be very rigid, its joints free moving but without any trace of slackness. The cutting spindle must be supported in such a manner that it is free to move in a plane parallel to the work under the guidance of the pantograph whilst being vertically rigid to resist the cutting

forces imposed by moving the cutter through the work.

My attachment achieves these objectives whilst its construction is well within the capability of the home engineer who is prepared to apply careful and accurate workmanship.

Fig. 1 shows a general view of the attachment fitted onto the milling machine. I will start the description with the cutter head assembly shown in section in Fig. 2. The barrels (2.1) consists of a piece of thick wall mild steel (or bored from solid) tube 1 1/2 in. O/D 4 1/2 in. long, machined circular and parallel to a good finish. It is bored through with a clearance hole and the ends machined to take two angular contact ball bearings of about 16 mm bore. Although not essential it is better if the top bearing is slightly smaller than the lower one as shown in the figure. Both outer races should be a good tight fit in the barrel and it is important that they are both concentric. This can be achieved in several ways, one being to hold the barrel in the four jaw chuck and set each end true with a dial indicator. Another way is to bore the central hole parallel and then mount the barrel on a stub mandrel turned on a short bit of rod held in the three jaw chuck. The outside can also be machined at the same setting as one of the bearing recesses. The other end is bored by reversing the barrel on the mandrel.

Whilst the spindle (2.2) can be made of mild steel, a piece of medium carbon steel such as EN8 is better if you can get it. Before making the spindle you have got to make a decision about the type of cutter you intend to use - or at least how you wish to hold them. My own choice is as drawn in the section of (2.2). The spindle is bored to take the standard 10mm diameter Boley draw collet chuck which I used on my small precision lathe (also home built).

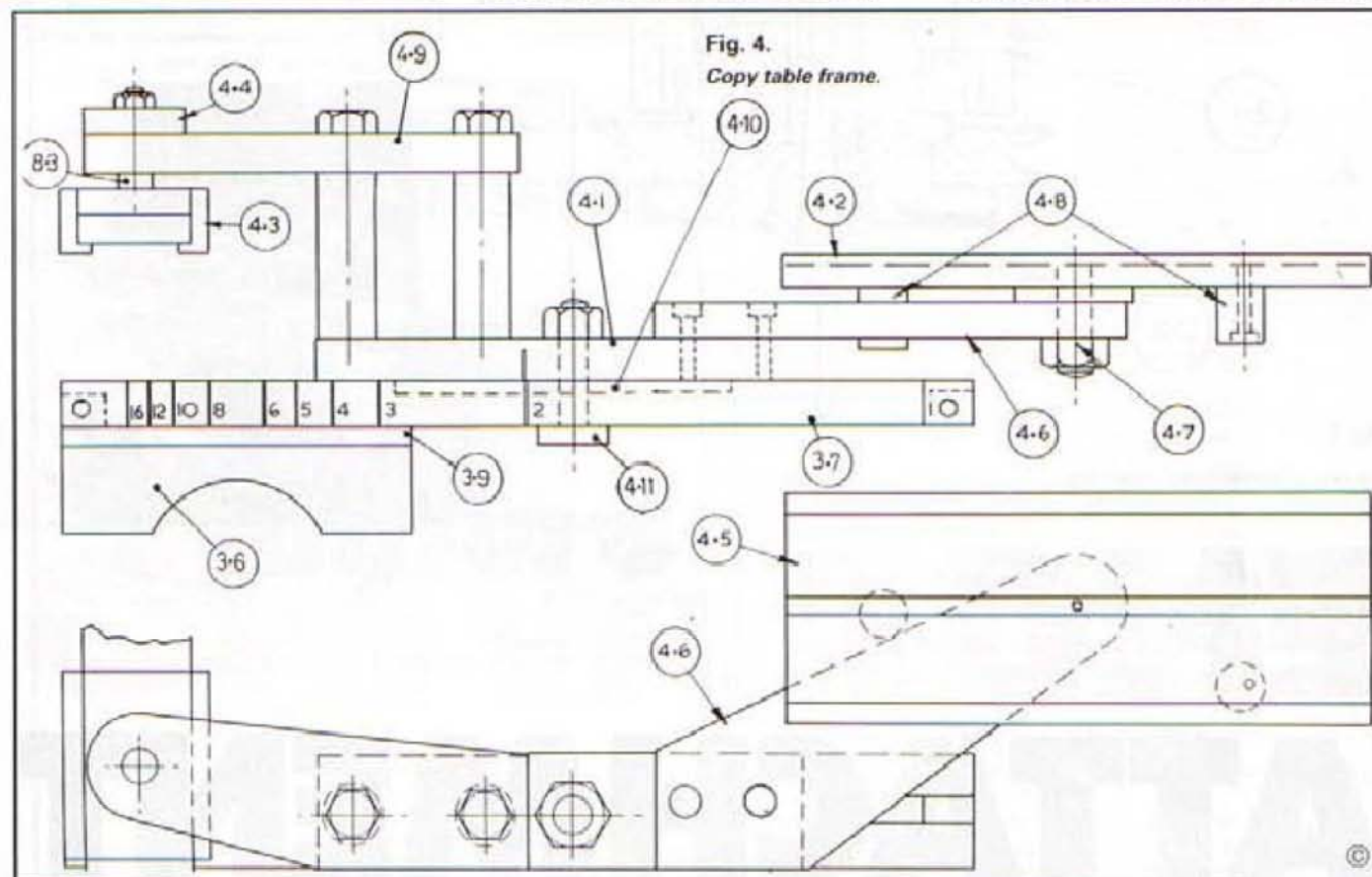
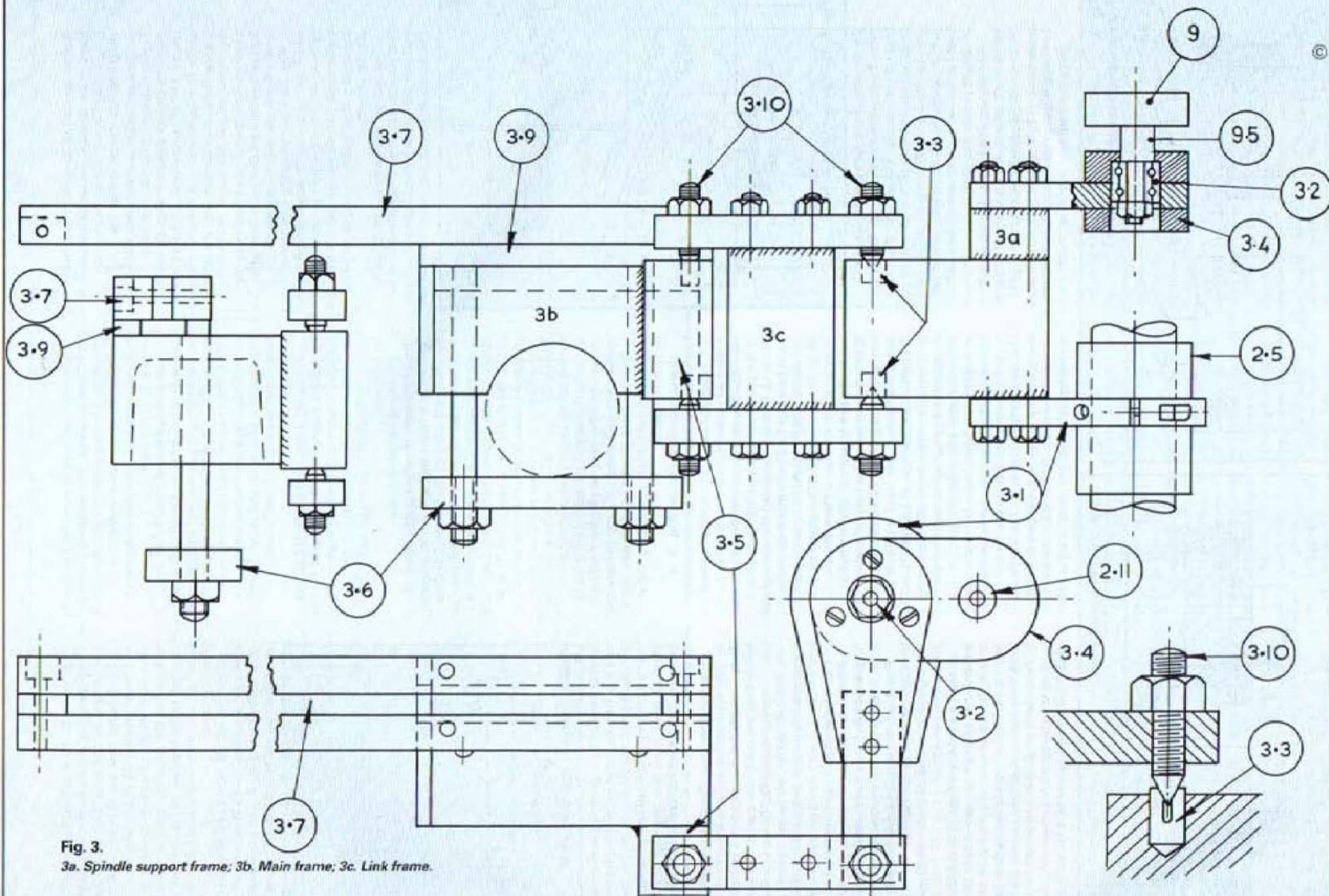


Fig. 4.
Copy table frame.



A draw spindle (2.3) is fitted to tighten them in the spindle. This enables me to hold parallel shank cutters made from silver steel as shown in Fig. 2a.

I also wished to use standard Rank, Taylor Hobson industrial engraving machine cutters shown in Fig. 2b which have a 1 in 14 taper shank. To hold these I made an adapter with the external shape of a draw collet, but not split, and the bore to suit the special R.T.H. taper. Incidentally, I used an old cutter ground down exactly half way to make a Dee taper reamer to finally finish the tapered socket.

Fig. 2b also shows the alternative in which the taper can be bored directly in the spindle. Whichever type you choose the cutter must be held rigidly and run true and some sort of split collet or taper socket is almost essential.

The spindle itself was bored through first then two centred plugs fitted in each end and the whole turned between centres. The screw thread for the adjusting nuts and

finally skimmed true by running the spindle in its own bearings. The pulley is a simple turning job from a piece of light alloy bar. It is important to have everything true to maintain balance so put a grub screw on each side of the boss.

Cast iron is the best material for the sleeve (2.5) in which the barrel (2.1) slides. I searched around a scrap yard and found an old machine collar from which to make mine. Steel can be used but needs well lubricating otherwise the two similar materials could pick up and seize. A better alternative is a piece of cast bronze or gunmetal.

Whatever is used it must be bored to a very close sliding fit on the barrel (2.1). The outside is machined leaving a lug on one end which is split and fitted with an adjusting screw (2.6) to enable any wear to be taken up.

The lifting flange (2.7) is a straightforward machining job, again of light alloy. It has a split and pinch screw to secure it to the top of the barrel (2.1). One end has a 0 BA tapped hole in it for the depth stop screw (2.8). In the other end is a larger hole to receive the bearing bush (2.9) of the rise and lower screw (2.10). This is an Acme thread of $\frac{1}{4}$ in. diameter and 0.1 in. pitch running in a bronze nut (2.11) and fitted with a large serrated wheel (2.12) for easy quick rotation. The length of the shoulder running in the bush (2.9) should be such that the plain shaft runs freely but without any end shake. The top flanged nut is fixed by three cheese head screws into a lug (3.4) on the spindle supporting frame described next.

This component, Part 3a, Fig. 3, is fabricated from various sizes of mild steel bar material. I bolted mine together and lined it all up carefully before finally welding. It is very important that the centre of the barrel sleeve clamp (3.1) and the barrel (2.5) are coaxial with the pantograph pivot bearings (3.2) and that this axis is parallel to that through the cone pivots (3.3). These pivots (3.10) and the similar ones on the main frame, Part 3b, are made of short lengths of $\frac{1}{4}$ in. diameter silver steel centre drilled at one end, hardened and pressed into close fitting holes as shown in the detail section in Fig. 3. Loctite Stud Lock could be used here if preferred. The main frame (3b) has to be designed to fit your particular machine. Later on I offer some suggested arrangements. Mine has a $\frac{1}{4}$ in. diameter overarm so the principle component of the main frame is a piece of 3 in. x $\frac{1}{4}$ in. channel steel, machined on the top face and radiused out in both flanges to fit the overarm. Two $\frac{1}{4}$ in. BSF studs, nuts and clamping plate (3.6) are fitted to secure the

attachment to the machine. A piece of $\frac{1}{4}$ in. plate is welded across each end to stiffen the flanges. On the back is welded a piece of 1 in. square steel bar (3.5) into which are two more pivots (3.3) of the type just described. Again care must be taken to ensure that the axis through them is at 90 degrees to the top face of the channel which in turn must be parallel with the machine table.

Bolted to the top face by four socket head screws is a slotted bar (3.7) to support the copy table frame Fig. 4. The bar is made up of two straight lengths of $\frac{1}{4}$ in. square

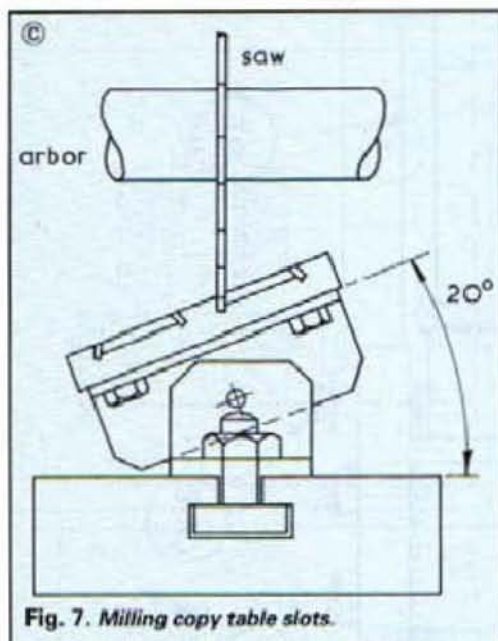


Fig. 7. Milling copy table slots.

the threads in the nuts themselves (2.4) must be screwcut to ensure the faces run true on the spindle. The seat for the lower bearing should be a light tap fit in the inner race (or use Loctite Bearing Fit taking care not to get any in the ball track!) whilst the seat for the top bearing should be a stiff sliding fit (no Loctite here!).

When assembled the nuts (2.4) should be carefully adjusted so that whilst there is no shake in the spindle there is no preloading. A light grease packing in the bearings will provide adequate lubrication.

The cone angle for the collet chuck is

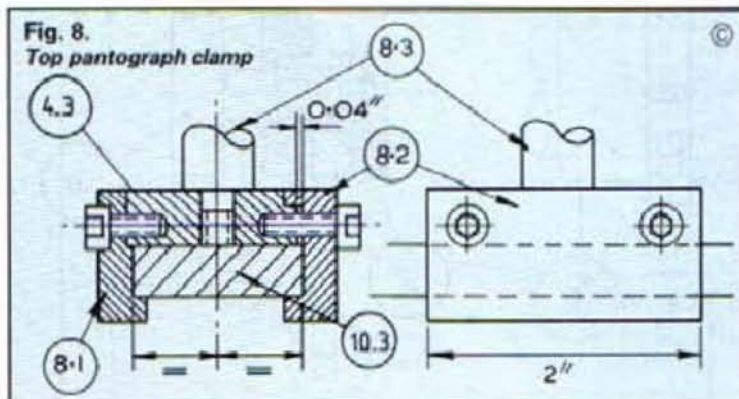


Fig. 8. Top pantograph clamp

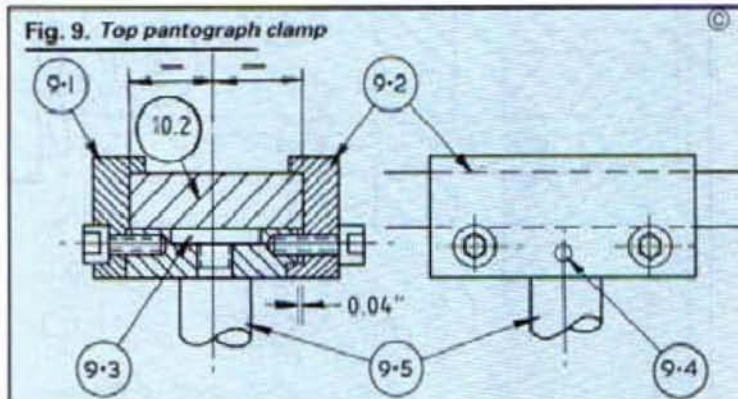


Fig. 9. Top pantograph clamp

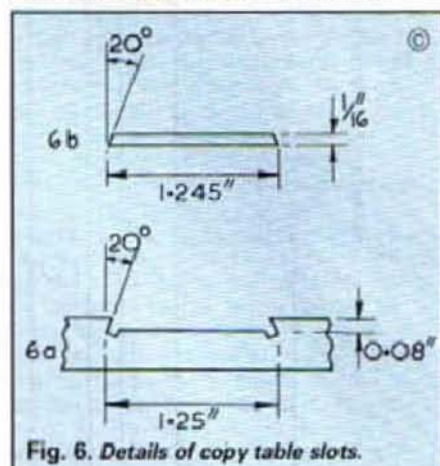


Fig. 6. Details of copy table slots.

steel separated by a packing piece at each end and held together by two socket head screws. To provide clearance for the copy frame clamping bolt head two packing strips (3.8) of $\frac{1}{4}$ in. x $\frac{1}{4}$ in. steel are fitted between the slotted bar and the channel steel base.

The link frame part 3c, which joints the spindle support frame 3a to the main frame 3a is a simple fabrication of two pieces of $\frac{1}{4}$ in. x $\frac{1}{4}$ in. welded to a piece of 2 in. x $\frac{1}{4}$ in. bar. The pivot screws (3.10) are threaded $\frac{1}{4}$ in. BSF with 60 degree cones turned concentrically on one end, case hardened and polished. Take care to get the two axes of the holes parallel in all directions.

When assembled the cone pivots should be grease lubricated and carefully adjusted to be free but without any shake.

Fig. 4 shows the copy table frame (4.1), the copy table (4.2) and the top pantograph clamp (4.3) in arm (4.9) and the bearings (4.4).

It can be seen from Figs. 1 and 4 that the frame is a bolted up assembly of the bearing bar (4.9) spaced from bar (4.1) by two tubes. The copy table bar (4.6) is fixed to (4.1) by two socket head screws. Fixed to the bottom of (4.1) is a $\frac{1}{4}$ in. thick guiding strip (4.10) to fit between the bars of (3.7). The locking bolt (4.11) needs two

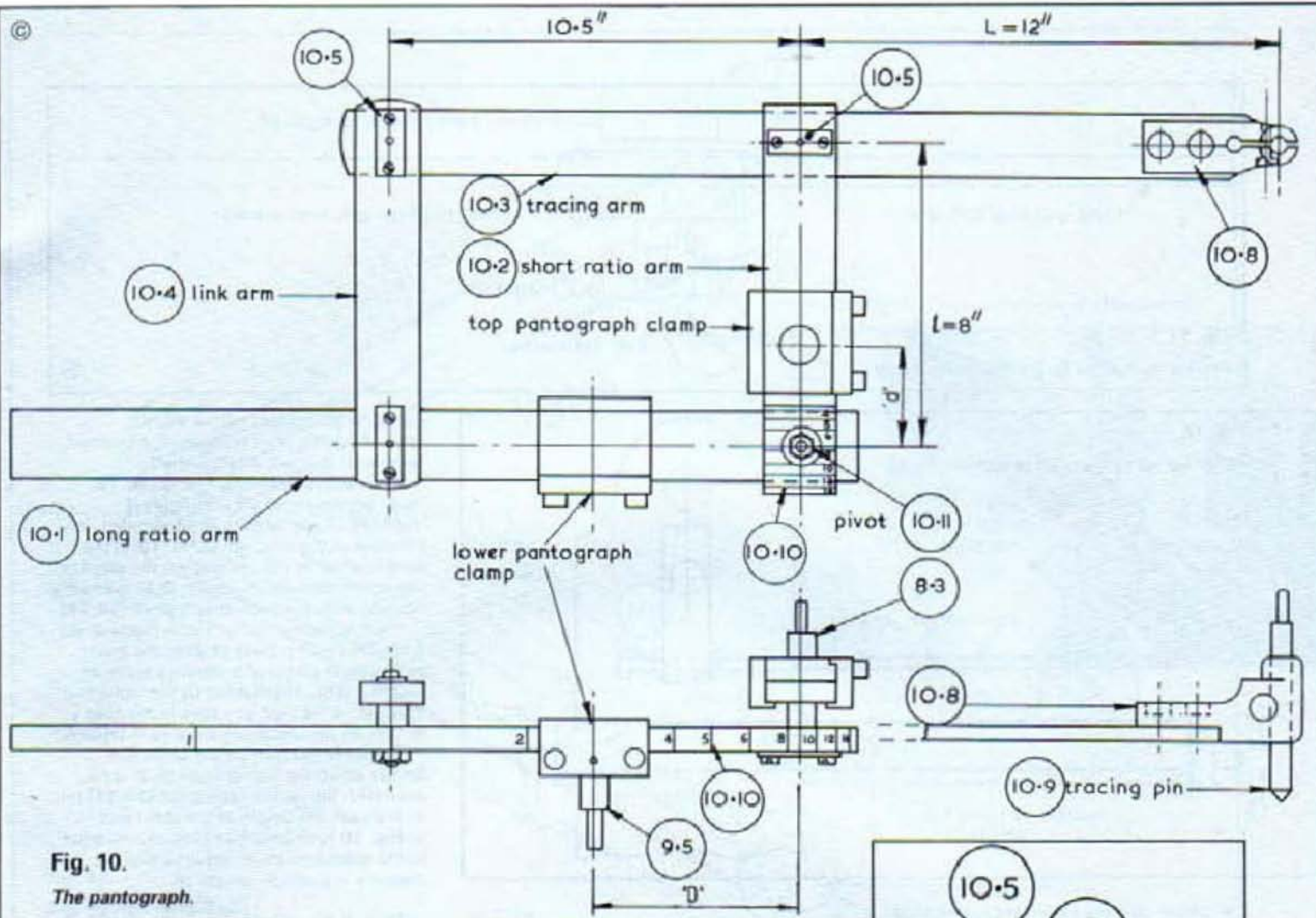


Fig. 10.
The pantograph.

flats and the end packing pieces between the bars (3.7) need to be below the top edge to clear the guiding strip. The pantograph clamp is shown sectioned in Fig. 5. The races, preferably angular contact type about 1/4 in. bore must be a close fit and adjusted up by the Nyloc nut (5.1) to be shake free.

Machining the copy table slots (4.5) might be a problem if you have no milling machine. In this case it could be made up of a flat plate with strips screwed and soldered in place after filing 20 degree angles on the edges. My copy table (4.2) is made from a 10 in. length of 3/16 in. x 1/2 in. mild steel. The slot edges were machined at an angle of 20 degrees with a 1/16 in. saw to the dimensions given in Fig. 6a. A wider saw or face mill was used to remove the waste material between the saw cuts.

I held the plate on the milling machine table by an improvised tilting angle plate made of four pieces of angle iron bolted in pairs. These were temporarily bolted to the bottom of the copy table and to the miller table as shown in Fig. 7. The size and angle of the slots was chosen to be the same as that used on industrial R.T.H. and similar engraving machines. I decided to do this as I was able to borrow some R.T.H. copy characters from which to make my own using the method described later. The table is secured to a hole in the bar (4.6) fixed to the frame (4.1) by a well fitting stud and nut in the centre. Two stops (4.8) are fitted on the underside of the table so that it can be rotated through 90 degrees if the work requires this. As it is important that there is no shift of position when sizes are changed the copy table slots must be set parallel (or at right angles) to the main

frame slot (3.7) carrying the copy table frame (4.1). To enable this to be correctly set the two stops are adjustable. Each one is a short piece of 1/4 in. diameter steel with the hole for the fixing bolts drilled eccentrically along the axis. Thus by rotating the steel cylinder slightly the angular position at which the table is stopped can be adjusted.

The top pantograph clamp Fig. 8, mounted on (4.9) and the lower clamp Fig. 9, mounted on (3.2) are made up of 1 1/4 in. x 3/16 in. steel 2 in. long with two milled pieces of 1 in. x 3/16 in. steel fixed to each side by 2 BA socket head screws. One side is permanently locked up tightly whilst the other can be released to allow the clamp to be slid along the pantograph arm to the required reduction setting and then locked.

As can be seen from the drawings the fixed plates (8.1) and (9.1) have slight locating steps milled on them whilst the clamp plates (8.2) and (9.2) have heels locating on steps in the main block thus ensuring correct clamping. The main 1 1/4 in. x 3/16 in. block of the lower pantograph clamp Fig. 9 differs from the top one in that it has a slot (9.3) milled in the upper face to clear the flat preloading spring (10.5) of the pantograph pivot.

It also has a locating pin (9.4) in the clamp plate to prevent any end movement due to clearance on the screws as the edge of this clamp is the fiducial mark for the various reduction settings marked on the edge of the long ratio arm. This pin is unnecessary on the top clamp as the edge of the main block forms the fiducial mark. Care should be taken to get the pivot studs (8.3) and (9.5) exactly in the centre of the width of the pantograph arms. To ensure

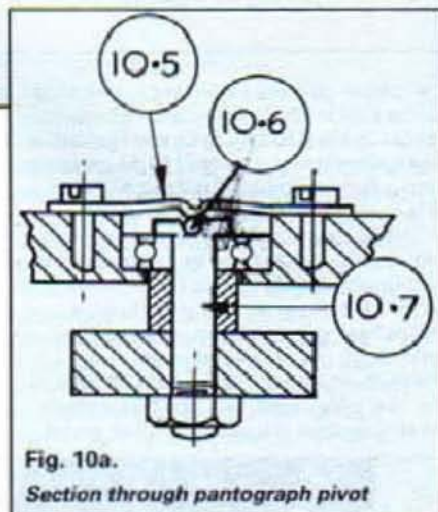


Fig. 10a.
Section through pantograph pivot

this the stud should have a short parallel portion engaging in the short parallel start of the tapped hole, Figs. 8 and 9.

Fig. 10 shows the pantograph assembly. Straight lengths of 1 1/4 in. x 3/16 in. steel are used for the pantograph ratio arms (10.1) and (10.2) whilst the tracing arm (10.3) is 1 in. x 3/16 in. and the link arm (10.4) is 1 in. x 3/16 in. steel. The various bearing hole centres must be carefully machined to the correct centre distances otherwise distorted characters will result. In particular the centre distances of the holes in the long pantograph arm (10.1) and the tracing arm (10.3) should be identical. Similarly the holes in the short pantograph arm (10.2) and the link arm (10.4) must be the same.

This is probably best achieved by drilling the pilot holes in pairs. A section through one of the four pantograph bearing assemblies is shown in Fig. 10a 5mm bore angular contact ball bearings were used although radial type could be used instead.

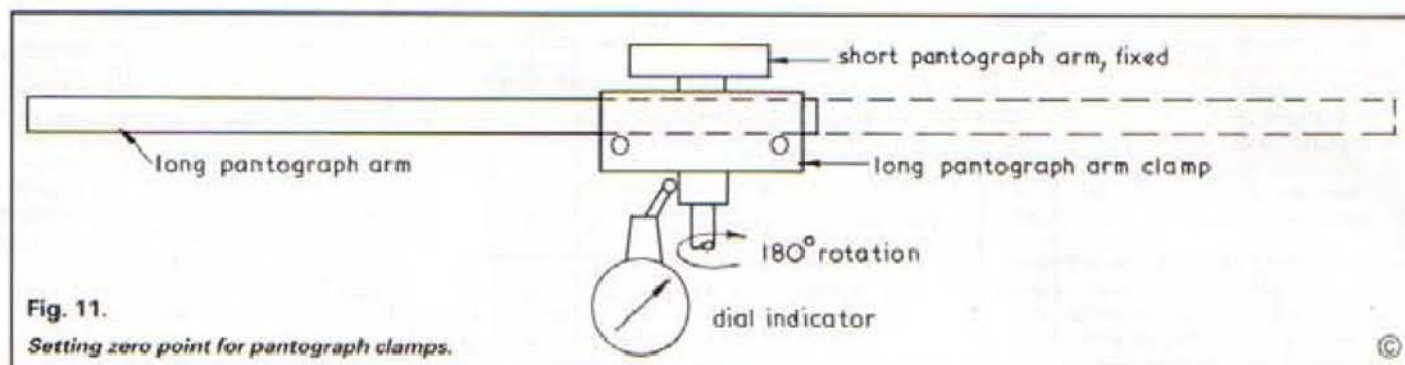
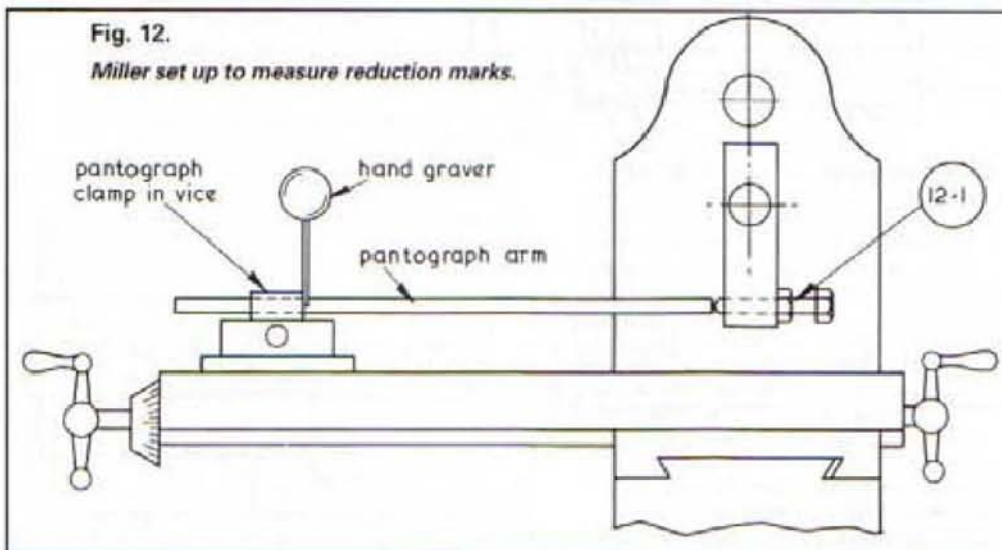


Fig. 12. Miller set up to measure reduction marks.



Pre-load to prevent any shake is provided by the 0.04 in. thick x 1/2 in. wide phosphor bronze or beryllium copper springs with a slight dimple in the centre (10.5) pressing onto a 1/4 in. steel ball (10.6) let in the end of the pivot bolt (10.7).

The tracing pin (10.9) is held in a light alloy clamp (10.8) fixed to the end of the tracing arm (10.3) by two socket screws. As the clamp is gripped by the fingers whilst tracing out the characters all the corners should be well rounded and polished. The tracing pin itself (10.9) is of 1/4 in. dia. silver steel, one end has a short parallel section 1/4 in. dia. The other end is

coned to 90 degrees with a slightly rounded point, both ends being hardened, tempered to straw and polished.

The reduction setting marks (10.10) must be measured off accurately if distorted characters are to be avoided. In the case of the long ratio arm (10.1) the zero position is obtained when the pivot of the lower pantograph clamp (9.5) is exactly co-axial with the pantograph pivot (10.11).

Each reduction mark is then made at the end of the clamp plate (9.2) of the lower pantograph clamp at a distance equal to length L (Fig. 10) divided by the reduction value from the zero position. In my case L is 12 in. so the distances were as in table A

Similarly the zero on the short arm occurs when the clamp pivot (8.3) is co-axial with the pantograph pivot (10.11) but in this case the length of the short arm '1' in Fig. 10 is divided into proportions equal to the reduction value required and the distance is given by length '1'

(1 + reduction value)

My '1' is 8 in. so the lengths are as in table B.

TABLE A

Reduction	Distance D	Reduction	Distance D
1:16	0.75"	1:5	2.4"
1:12	1.0"	1:4	3.0"
1:10	1.2"	1:3	4.0"
1:8	1.5"	1:2	6.0"
1:6	2.0"	1:1	12.0"

TABLE B

Reduction	Distance 'd'	Reduction	Distance 'd'
1:16	0.47 inches	1:5	1.333 inches
1:12	0.615	1:4	1.6
1:10	0.727	1:3	2.0
1:8	0.888	1:2	2.667
1:6	1.142	1:1	4.0



Fig. 13. Spindle drive and motor.

To measure these distances accurately I first set the zero point by clamping the short ratio arm in the vice and rotating the long arm through 180 degrees, checking the movement of the lower pantograph clamp pivot with a dial test indicator as shown in Fig. 11. The zero position is indicated by the point at which there is no indicator movement.

Actual distances were measured on my milling machine using the traverse screw and index. The block was gripped in the machine vice, Fig. 12 with a stop (12.1) rigidly clamped to the machine and adjusted to just touch the end of the pantograph arm when at the zero position of the clamp.

With the pantograph clamp screws adjusted so that the arm slides stiffly through the traverse is moved the requisite distance by means of the screw and index. This causes the arm to be pushed through the clamp the correct amount. At each position the setting mark was cut by means of a narrow hand engraver held against the

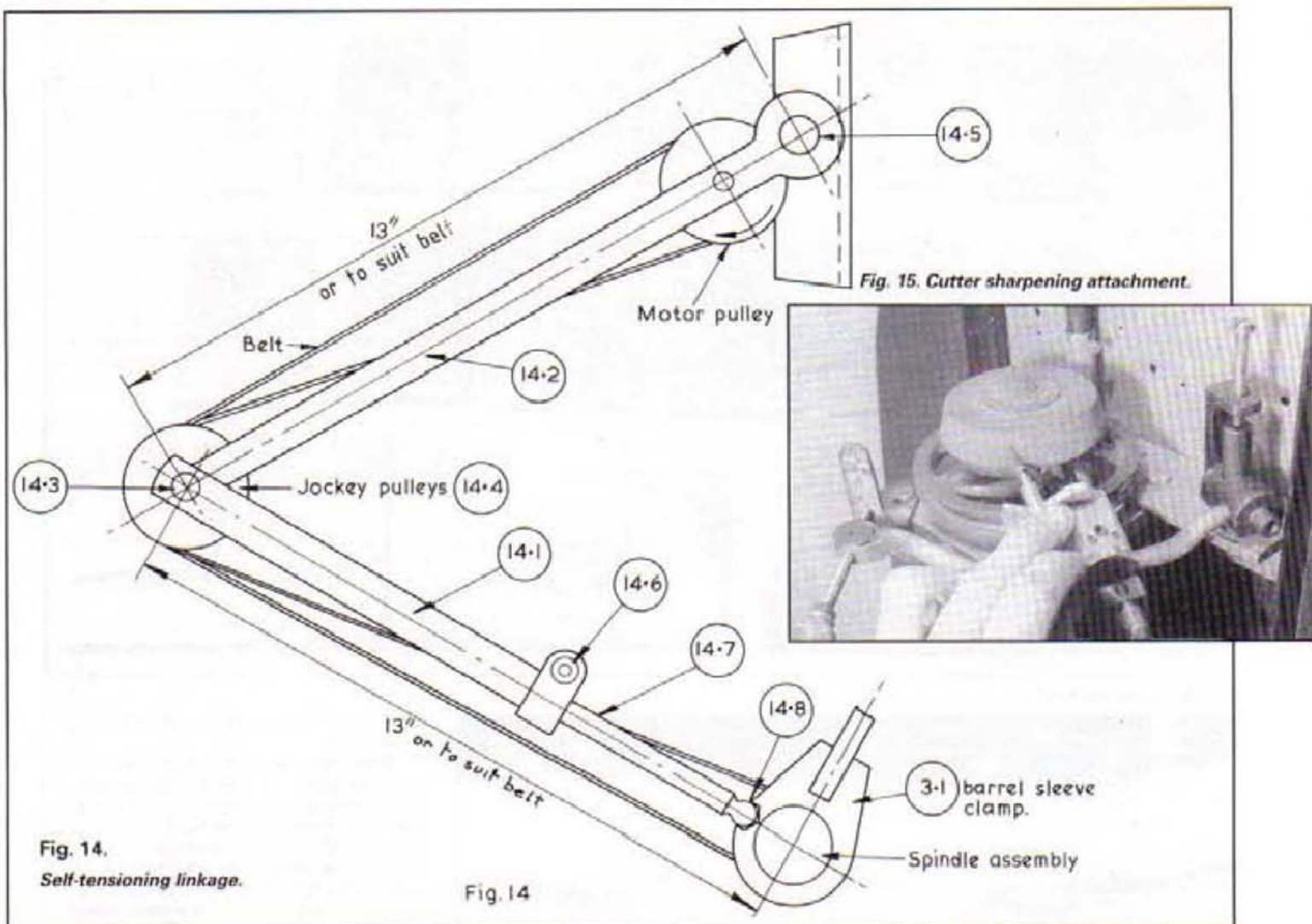


Fig. 14.
Self-tensioning linkage.

edge of the clamp plate.

A similar procedure was used for marking the short ratio arm reduction marks. Marks are also needed on the slotted bar (3.7) which supports the copy table frame (4.1). These marks can be seen in Figs. 1 and 4. Zero points in this case is obtained by setting both upper and lower pantograph clamp pivots approximately co-axial with pantograph pivot (10.11) and the tracing pin in the central hole in the copy table. The copy table frame is then adjusted along the slotted bar until the spindle supporting **Frame 3a** is approximately at right angles to the line of the slotted bar as shown in Fig. 3 plan view. The distances are then marked off from this point, those used for the long arm being used. As the setting of the position of the copy table frame is not so critical as the setting of the ratio arms a little less precision is adequate for these marks.

The figures are carefully marked with figure stamps held against a guide to keep good alignment. Any metal raised up in the process is carefully levelled off with a smooth file. They could not be engraved for obvious reasons! The figures and lines are then filled with black paint.

The cutter spindle is driven by means of a continuous round belt, preferably of spliced cord. To give a spindle speed of about 7000 rpm, suitable for most work there is about a 2½ to 1 step up from a ¼th HP 3000 rpm motor mounted on the main framework of the milling machine.

Figs. 1 and 13 show the arrangement on the miller whilst Fig. 14 shows the linkage arrangement to ensure that the belt tension remains constant diagrammatically. It



Fig. 16. Sharpening socket, cutters and cutter spanner.

consists of two tubular arms (14.1) and (14.2) pivoted together at (14.3). Also on an extension of the pivot are two ball bearing jockey pulley wheels (14.4) about 1½ in. diameter. The whole linkage is supported by a bearing on the end of the arm (14.2) which fits on a ¼ in. dia. stub axle (14.5) fixed to the motor supporting frame, also seen in Fig. 13.

Arm (14.1) has a clamp (14.6) at its end which locks the ¼ in. dia. steel rod (14.7). This rod has a ball end (14.8) which is located in a socket in the barrel sleeve clamp (3.1). The rod is pulled and locked by the clamp (14.6) to give the correct belt tension. The belt is crossed so that the spindle rotation is clockwise when viewed from the top.

While discussing the motor it is worth mentioning that above the pulley is mounted a grindstone for cutter sharpening also seen in Fig. 13 and in

detail in Fig. 15. A special adjustable vee rest, seen in foreground of Fig. 15 is used to support the sharpening socket seen top left on Fig. 16 laying on top of the cutter spanner. This socket has a locating shoulder and a taper bore into which the cutters are fitted for sharpening. The adjusting screw on the left in Fig. 15 is set so that the cutter just touches the stone when the sharpening socket shoulder is held against the vee rest. The socket is partially rotated anticlockwise, starting at the heel of the cutter and stopping at the cutting edge to produce relief.

Depth of cut is set by turning the adjusting screw. For normal work the rest is adjusted to produce a cutter angle of 90 degrees although other angles, or parallel, can be used for special purposes.

Standard cutters for RTH machines are available from tool merchants (usually to



Fig. 17. Vice for holding copy blanks during engraving.



Fig. 18. Examples of copy.

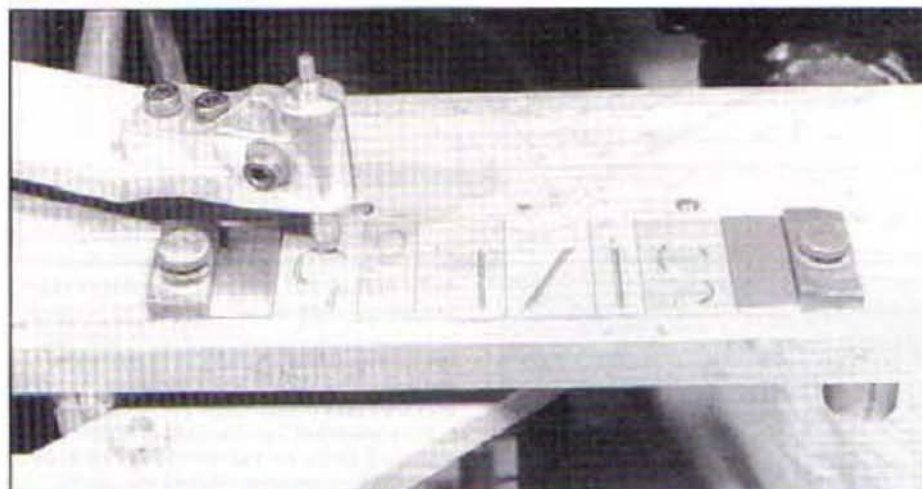


Fig. 20. Copy table with copy in place and tracing pin.

hole in the sharpening holder is also concentric.

Before you can do any engraving you will need copy characters. These can be obtained in several ways. You can buy a set for an industrial type machine or alternatively, if you can borrow one of each character you can make your own on the attachment by 1:1 copying. This was the method I used to make the normal letters and figures. You can also make a master character of each letter or figure by normal end milling; straight lines are easy, curves could be cut from metal or plastic sheet and traced around. Draughtsmen's stencils, such as the larger UNO or Rotring stencils, can with adaption be used directly as copy, either normal or reversed, or to produce your own metal characters. The tracing pin needs a parallel end to fit the stencil slot

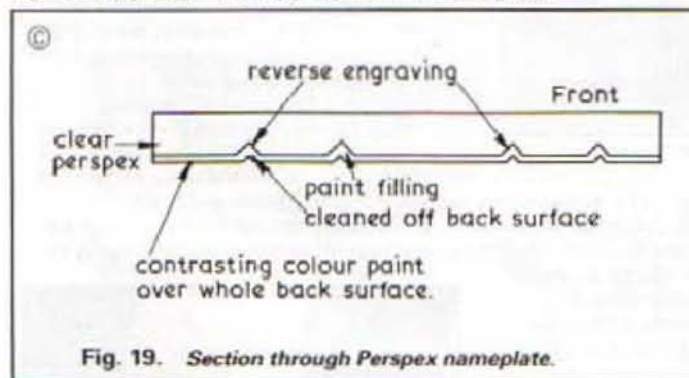


Fig. 19. Section through Perspex nameplate.

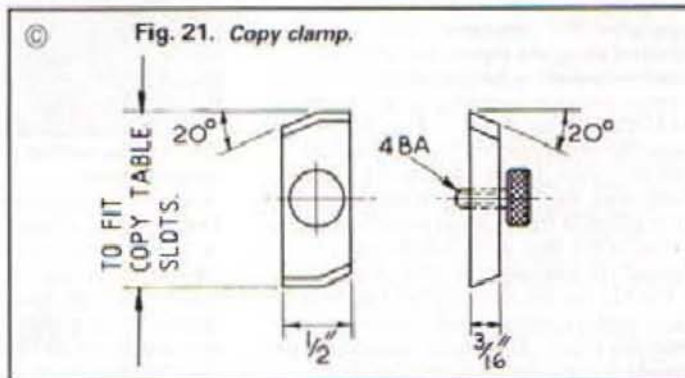


Fig. 21. Copy clamp.

QUICK TIP

Make a habit of locking the tailstock of the lathe to the bed when not in use, if tipped up inadvertently, a piece of swarf can so easily be trapped underneath unnoticed, throwing the tailstock centre out of true.

P.A. Twist

order) but quite satisfactory ones can be made of silver steel. If making the taper shank type set the lathe to turn the 1 in 14 taper then turn a considerable number shanks whilst the machine is set up. One can be used to make a dee reamer to machine the socket. The dimensions are given in Fig. 2b.

Should you prefer simple parallel shanks about 1/4 in. or 6mm diameter is adequate. It is essential that they are held to run perfectly true in the spindle (2.2), either by a collect chuck or other means and that the

and some resetting will be necessary on discontinuous characters such as B and whilst those characters which are outlines such as O will need care. Although industrial copy characters are of brass, light alloy is quite adequate for less rigorous amateur use.

Strips of 1/8 in. x 1 1/4 in. material (or sheet cut up) having the edges milled with 20 degree angles to the sizes given in Fig. 6b are prepared first. Take care to keep the strips parallel and to size. If you haven't got a 20 degree angle cutter either make a

flycutter by grinding the end of a tool bit to the angle **Fig. 24** or hold the strips at an angle by some convenient means. Make a good supply of strips while you are at it so that you don't have to set up again. Cut off the pieces to the correct length for the characters using the milling machine with a saw so that the ends are square and parallel. The table below gives the lengths for each character and the usual number included in a set. Spacers do not need angled edges so can be cut from odd pieces of strip or sheet material.

A variety of widths are an advantage but they must be parallel.

The photograph (**Fig. 1**) shows my



Fig. 22. The work table.

Table of Characters						Mirror	
Char.	Width.	No.	Char.	Width.	No.	Char.	No.
A	17	4	&	18.5	2	B	2
B	18	3	1	9.8	3	C	2
C	18.5	2	2	12.4	3	D	2
D	18.5	3	3	17.4	3	E	2
E	18.5	6	4	16.6	3	F	2
F	17.6	3	5	18.3	3	G	2
G	18.5	2	6	18.4	3	J	2
H	19.5	3	7	16	3	K	2
I	9.8	3	8	18.4	3	L	2
J	14.3	2	9	18.5	3	N	2
K	18.5	2	0	19	3	P	2
L	16	4	+	17.5	1	Q	2
M	23	3	-	14	1	R	2
N	19.5	3	.	7.5	1	S	2
O	19	4	~	7.5	1	Z	2
P	17	2	:	7.5	1	3	2
Q	19	1	;	7.5	1	4	2
R	17.8	3				5	2
S	18.5	4				6	2
T	18	4				7	2
U	18.5	3				8	2
V	18.5	2				9	2
W	21.5	3					
X	18.5	1					
Y	18	2					
Z	18.5	2					

machine set up on 1:1 for direct copying characters and **Fig. 17** shows a close up of the special vice clamp to position and hold the blanks during machining the groove. This character groove should be 90 degree angle and about 0.07 in. (1.8mm) wide at the top. When setting up for the first cut, the spindle (2.1) is lowered down to the stop (2.8). The main milling machine table is raised until the work surface is close to the cutter, the work then being correctly positioned by moving the horizontal traverses. When satisfied the motor is started and the milling machine vertical table feed raised using the left hand whilst the right hand moves the tracing pin around the copy until the correct depth is obtained. The cutter is then lifted from the work by rotating the serrated wheel (2.12). The milling machine vertical traverse setting is left untouched when machining all further characters. At first it is difficult to follow the tracing pin around the copy and watch the work at the same time. However this problem is soon overcome as the knack of co-ordinating both hands and eye is acquired.

Some of my home made copy, both

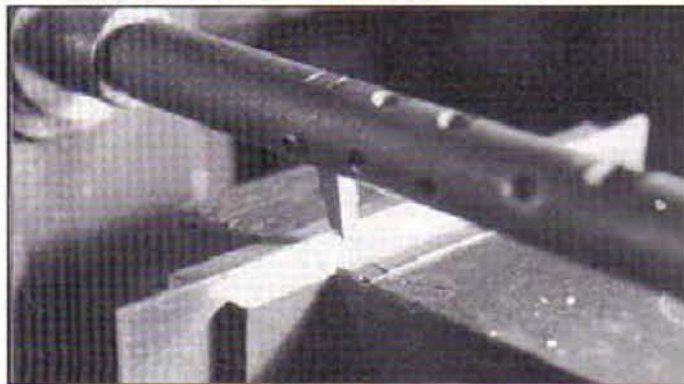


Fig. 24. Milling master copy strip with angled fly-cutter.



Fig. 25. Generating a mediaeval '4' master copy.

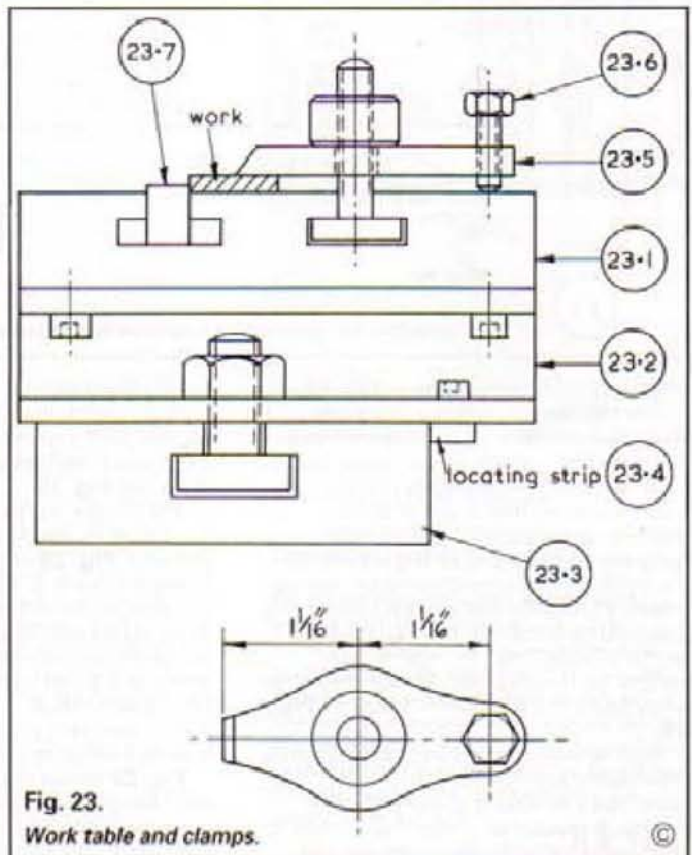
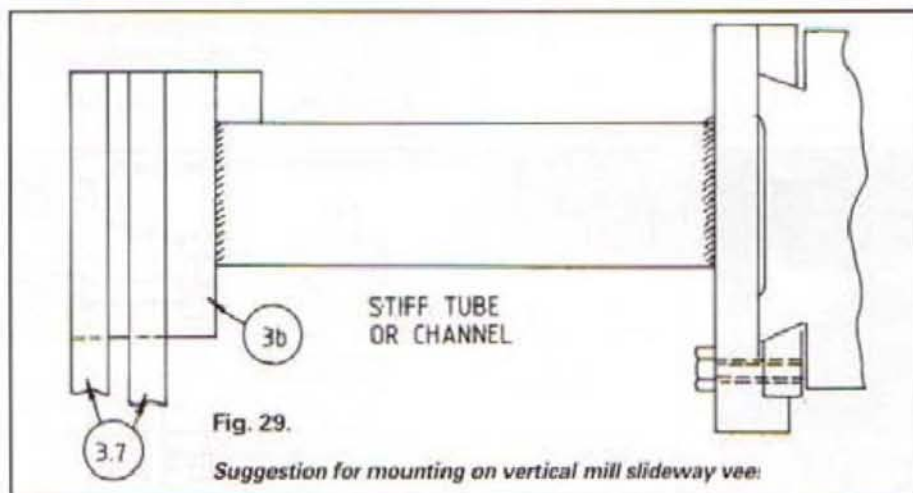
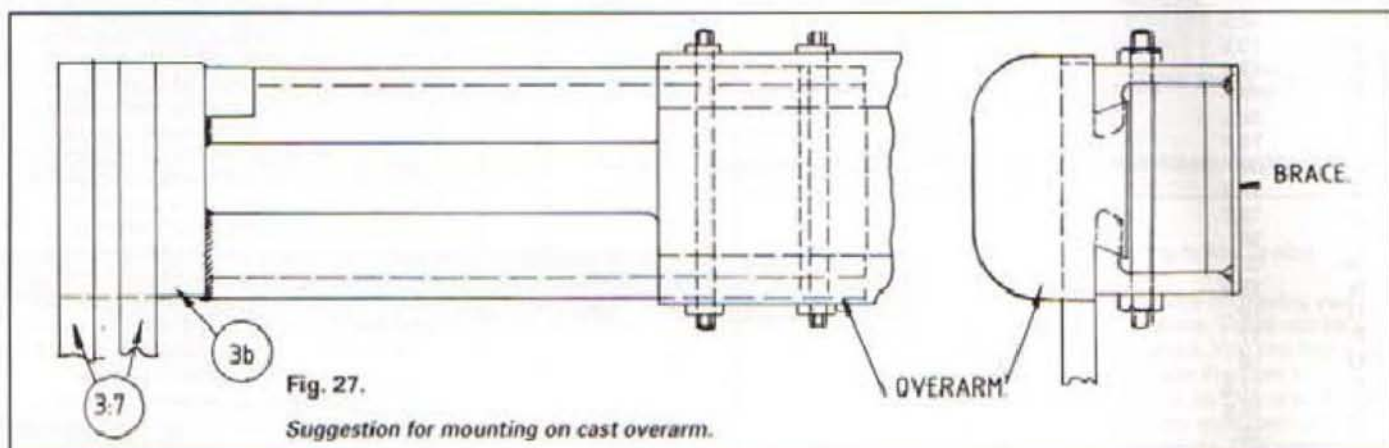
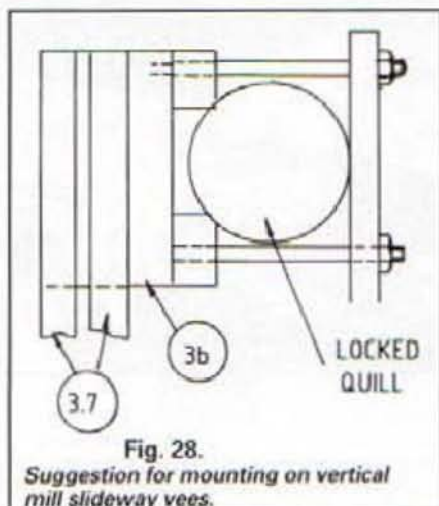


Fig. 23.
Work table and clamps.



brass and light alloy is seen in Fig. 18.

The top row are ordinary standard characters traced 1:1 from industrial copy. In the middle row are special numerals made without a master copy and the bottom row another group of special masters. These last two groups were generated by a 90 degree angle end mill in the normal vertical head using the milling machine traverses and circular movements imparted by mounting the character blank on the dividing head set with its axis vertical. By the way, 'IBI' on the bottom row is my 'trade mark' master - 'I Built It'. Fig. 25.

Each special master has to be dealt with individually and often many careful resettings are needed to complete the outline. A reverse or 'mirror' set of copy is very useful for engraving in the back of

transparent material. When filled with coloured paint, then the back surface painted with a contrasting colour this technique produces a very effective name plate, see Fig. 19.

The standard copy is located in the copy table slots by means of the simple stops shown in Fig. 20 and detailed in Fig. 21. These are made of $\frac{1}{8}$ in. x $\frac{1}{8}$ in. steel with the ends milled or filed as shown to enable them to be easily dropped into place. The 4 BA locking screws need low flat knurled heads to prevent interference with the tracing arm (10.3).

Non standard copy can be held by tool makers clamps as convenient.

Fig. 22 shows the work holding table and clamps in use, an accessory which is often more convenient to use than mounting work directly on the miller table

or in the vice.

In my case the table is a piece of light alloy plate, detailed in Fig. 23, with two $\frac{1}{8}$ in. tee slots milled along it, (23.1). To it are bolted two pieces of channel steel (23.2) with the flanges milled parallel.

These in turn have holes to receive bolts for fixing to the miller table (23.3). An alignment tongue (23.4) either locating in the miller table tee slot, or on the edge of the table reduces setting-up time.

Also shown in Fig. 23 are the work holding clamps (23.5) which can be cut from $\frac{1}{8}$ in. mild steel. A knurled nut is fitted to the tee headed bolt and the heel (23.6) is a hexagon headed 0 BA or $\frac{1}{8}$ in. BSF set screw with a slightly radiused end. I keep a small piece of masking tape stuck on the tip of the clamp to avoid damaging the work. Another time saving addition is to wedge a piece of strip (23.7) in one of the table tee slots to provide an alignment face for the work.

It is a useful exercise to make a size plate of white Perspex by engraving 'SIZE 3' 'SIZE 4' etc. in each of the size settings from the largest to the smallest, shown being engraved in Fig. 26. This is a handy tool for choosing the size setting to use on any job being engraved.

When setting up the first job is to choose the size then set pantograph clamps and the copy table frame on the appropriate reduction marks. A sharp cutter is put in the spindle and the selected copy in the copy table slots. Note that these should be upside down when viewed from the front if the work is to be the right way up. They are spaced symmetrically about the centre of the copy table, and can with advantage be lubricated with a trace of oil. The cutter

Fig. 31.

Suggested fabricated framework with co-ordinate table.

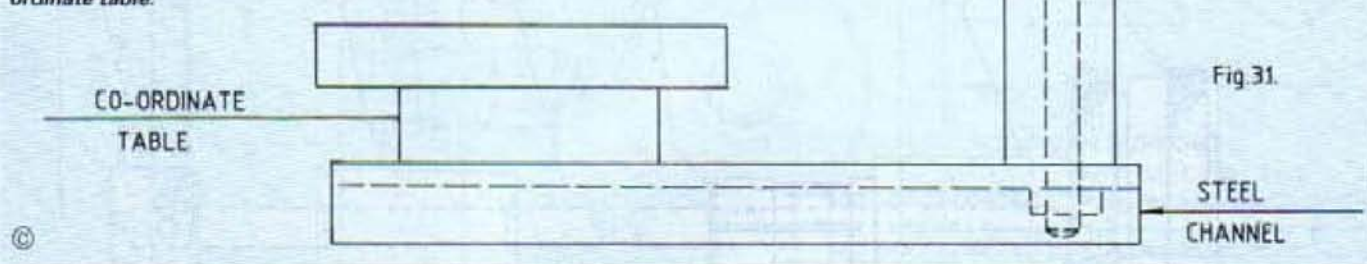


Fig. 31.

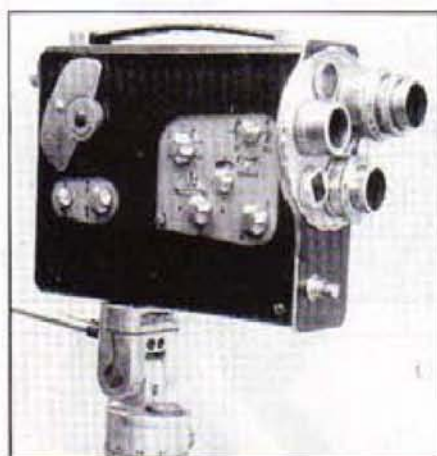


Fig. 32. Cine camera showing engraving on controls.

feed (2.12) is wound fully down to the stop (2.8) and the tracing pin put in the centre of the row of copy. The miller table is then wound up until the cutter point is close to the work surface and the correct position obtained by moving the horizontal traverses as described when making the copy. By tracing the pin round the copy and watching the cutter it can be ascertained that size and position are correct. When satisfied, start the cutter and gradually raise the work and move the cutter as described earlier. When the right depth, go round the character twice, lift the cutter from the work by the serrated wheel (2.12) taking care not to allow the tracing pin to come out of the copy groove until the cutter is clear of the work. Pass the tracing pin to the next character and gradually lower the cutter again whilst moving the tracing pin in the groove. Carry on repeating the operation on each character in turn. A little cutting oil can be helpful on certain materials. A 1/2 in. paint brush is useful for dusting the swarf away from the cutter during the process. If not sufficiently deep the miller table can be raised slightly more and the characters re-traced provided the horizontal traverses have not been moved. Always check work carefully before unsetting because it requires considerable skill and care to pick up the engraving again.

The work can be left, unfilled, but looks much better if filled with paint, warmed and sealing wax, or soft wax crayon of a suitable colour. It is rubbed in then the surplus wiped off the surface with a piece of rag wrapped round a steel rule or flat blade.

It is worth remembering that the machine can be used for many other purposes than plain engraving nameplates,

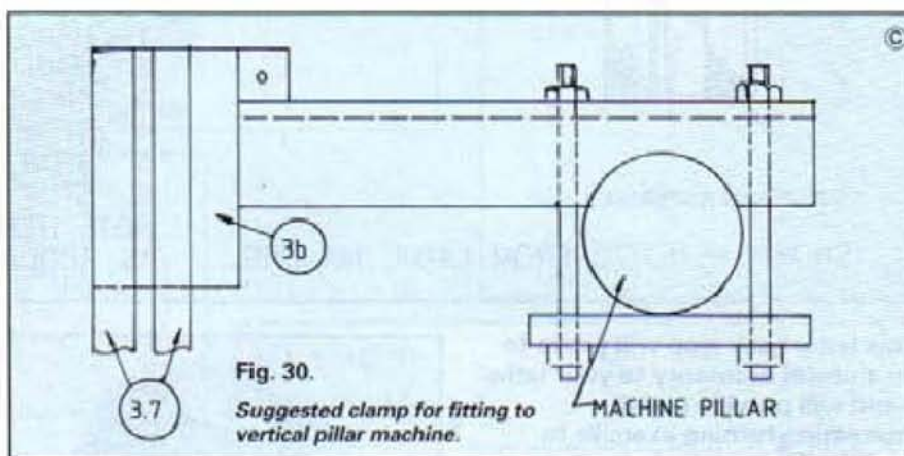


Fig. 30.

Suggested clamp for fitting to vertical pillar machine.

etc. For example by using a flat ended cutter and suitable copy sunken background plates can be made, also non circular 'O' ring grooves.

As mentioned earlier this attachment fits onto the circular overarm of a horizontal milling machine. Many older machines such as the Senior, Ajax, Zytro, Portass, etc. have similar circular overarms, although probably of different diameters. Machines such as the Centec, Elliot, Harrison, Omnimill, etc. have a cast arm with vees on the bottom face. Fig. 27 is a suggested possible approach. Two pieces of stiff angle could be welded to part 3b, Fig. 3, machined with vees at the outer ends possibly with a brace piece across the end. Two pinch bolts pull them together to clamp onto the overarm vees. For vertical mills it may be possible to clamp to the quill as Fig. 28. Obviously the quill must be locked. Alternatively it may be possible to weld a piece of square tube or channel to part 3b and weld a clamp on the outer end to fit the vertical slide vees as Fig. 29.

Adaption to machines with a vertical circular pillar might be dealt with as Fig. 30. If a co-ordinate table is available then this could be fitted to a pillar drilling machine or even to a fabricated framework Fig. 31. Also fixed to the framework would be the motor. As the traverses are only used for positioning the work they can be relatively simple slides without accurate screws or index collars. Even a vertical adjustment is not essential as depth can be set by adjusting the stop screw (2.8), the work being mounted on packing to bring the working surface within the travel range of the barrel (2.1).

Finally, Fig. 32 illustrates one of the first jobs to be engraved, the controls and nameplate on my home build cine camera whilst Fig. 33 shows one of the more recent projects, the perpetual calendar of

my replica Dondi mediaeval clock. This project involved engraving over 11000 characters needing nearly 100 specially made master copy characters.

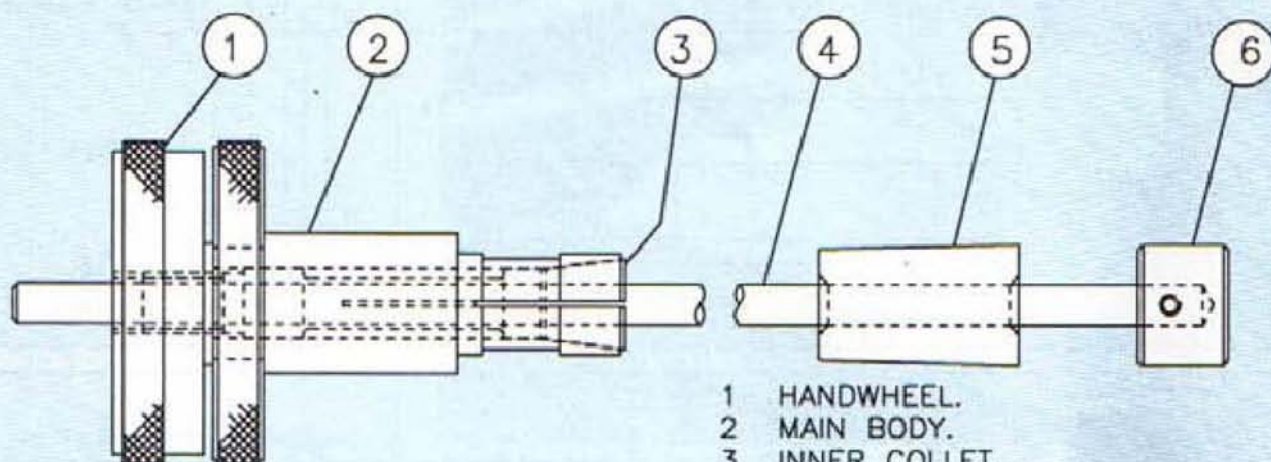


Fig. 33. Replica Dondi clock, perpetual calendar with front removed.

QUICK TIP

When cutting an open ended slot with a slot drill, take extra care when entering and leaving the slot, especially with cast iron. The cutter is liable to catch on, and break off a corner, so traverse very slowly until the slot drill is well into or out of the slot. End mills whilst not so good for cutting slots, are not so liable to catch on a corner.

P.A. Twist



STOP BAR ASSEMBLY

SHOWN REMOVED FROM LATHE MANDREL.

- 1 HANDWHEEL.
- 2 MAIN BODY.
- 3 INNER COLLET.
- 4 STOP BAR.
- 5 STOP BAR SUPPORT.
- 6 STOP PIECE.

NOTE ITEMS 5 AND 6 ONLY FITTED AS REQUIRED.

This lathe back stop will prove to be a useful accessory to your lathe – and will provide some interesting turning exercise to complete it

Making a number of identical length components on the lathe can be a frustrating and time-consuming operation. This due to the necessity to continually remove the part from the chuck for measurement, and replacing it for further machining.

The situation can be made additionally complex if there is a need for a high degree of concentricity, which may be lost due to the removal from the chuck.

The solution is to use an adjustable backstop mounted through the lathe mandrel, and for the item being machined to be placed against this when fitting the part in the chuck. By machining the first part and taking note of the machine dials, subsequent parts can then easily maintain similar dimensions.

If the requirement to remove the first part from the chuck is unacceptable, as this will spoil concentricity, then the initial dimensions with regard to length can be established using a scrap piece of material before making an actual part.

The backstop can also be of use for turning single parts in some applications. Again, where faces being machined are critical with respect to the hidden face and concentricity is also important, then if the back stop is set to a known dimension from the face of the chuck, subsequent machining can be checked with reference to this face without the need to remove the part for measuring.

The method of measurement can be chosen depending on the level of precision necessary; in some cases a rule will suffice whilst in others a depth micrometer would be required.

Another use for the back stock is to assist in positioning larger and relatively thin parts in the chuck, with the faces running true. This is not intended to



The set of parts for the back stop; stop bar support is not shown.

A LATHE BACK STOP

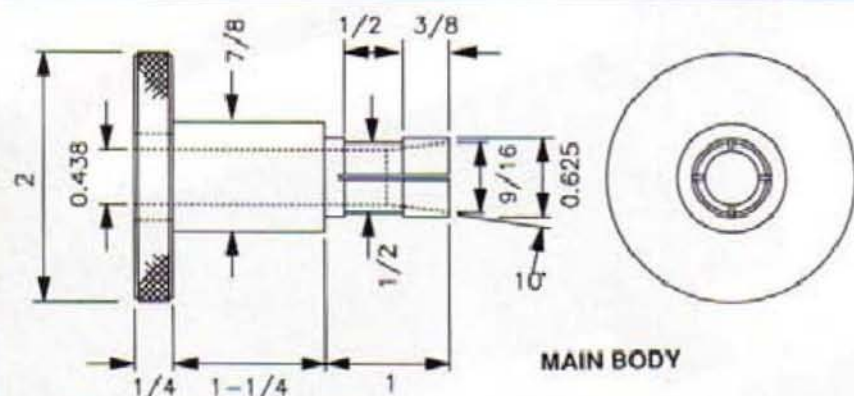
replace the requirement for special thin piece chucks for the very thin parts, but even a part, say, one inch diameter and one half inch thick, can easily take up an out-of-true position, when being placed in the chuck.

To achieve this aim, the back stop rod is fitted with a larger stop face, this for the part to rest against when being fitted into the chuck. For additional precision a stop bar support is fitted in the mandrel taper, suitably drilled with the correct size hole to support the stop bar.

The design

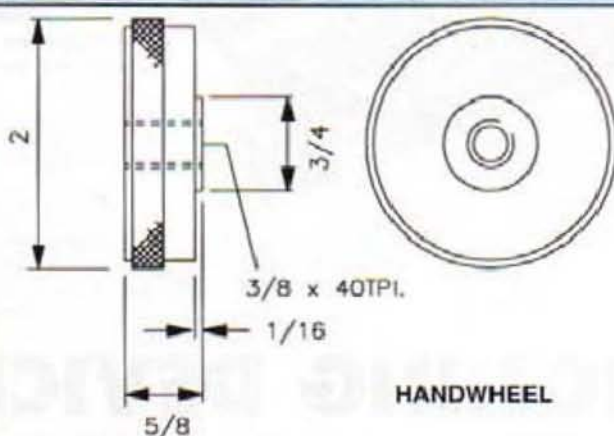
The essential requirement for the back stop is for it to be adjustable. The only practical method for achieving this is for it to be done using a rod which passes through the complete length of the mandrel bore, and for it to be fixed at the change wheel end, and in a manner that permits adjustment to take place.

In the design adopted, fixing the assembly to the mandrel and also fixing the stop bar are done in the same

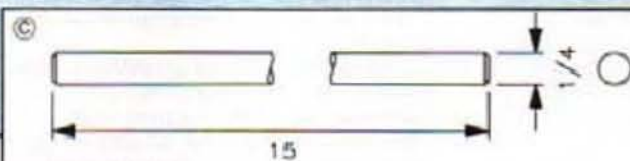


MATERIAL: 7/8 INCH DIA. BRIGHT MILD STEEL.
2 INCH DIA. BRIGHT MILD STEEL.

© MADE FROM TWO PARTS LIGHTLY RIVET TOGETHER.



MATERIAL: 2 INCH DIA. BRIGHT MILD STEEL.



STOP BAR

MATERIAL: 1/4 INCH DIA. BMS.

ALL DIMENSIONS IN INCHES

operation. This is made possible by the inner collet being split, enabling it to grip the bar passing through it, but at the same time, due to the main body also being split, this will be expanded to grip the bore of the lathe mandrel.

The large diameter wheel on the main body may at first appear superfluous, but this is to enable the complete assembly to be removed easily after use. If an attempt is made to remove the assembly using the handwheel, the result will be for the inner collet to expand the main body and to capture the assembly into the mandrel bore, even though the handwheel has been loosened.

Dimensions included in the drawings are those to suit a Series Seven Myford Lathe but the design can easily be adapted to suit any other size of lathe.

Manufacture

There is very little to be said with regard to manufacture, as nothing is very critical or complex. The main body is shown as being made from two pieces to minimise the amount of machining and metal used, the parts can either be riveted together or

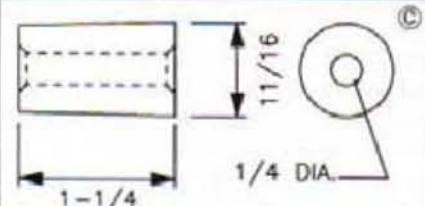
fixed using a suitable adhesive, though if wished this could be made from one piece. If made from two pieces, make both wheels at the same time, if for no other reason than the fact that this enables the knurling to be done in one operation.

In use

Very little explanation is required regarding using this device; where it is being used to position a number of relatively simple components, all that is needed is for the bar to be positioned approximately. The first part can then be machined, removed and measured, returned for final machining, establishing the dial readings to be used for making subsequent parts.

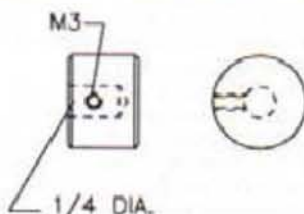
If a single critical part is to be made the bar's position can be measured, either from the face of the chuck or the end of the chuck jaws using a depth micrometer, and for all measurements of the part being turned then to be taken relative to this face.

To avoid failures do ensure that both the bar end and the part to be machined are clean when a new part is inserted for machining, or errors will result.



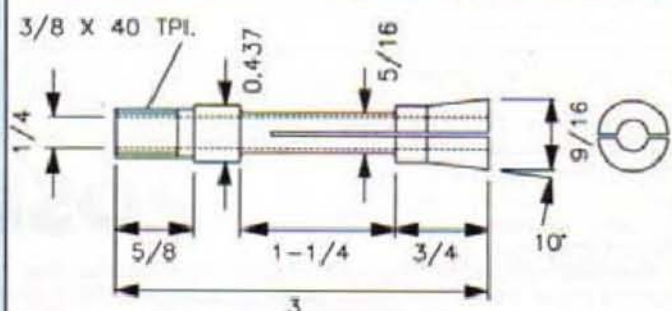
STOP BAR SUPPORT

MATERIAL: 3/4 INCH DIA. BMS
TAPER AS PER No. 2 MORSE TAPER.



STOP PIECE

MAKE TO SIZES REQUIRED.



MATERIAL: 5/8 INCH DIA. BRIGHT MILD STEEL.

INNER COLLET

QUICK TIP

I expect that most model engineers, like me, cannot always work continuously on their projects. This means that some parts may be stored in a half-finished state for some time. It is very aggravating to find that a part which was marked out the last time it was looked at is no longer clearly marked, because the spirit marker or whatever was used has faded, or been rubbed off. More permanent marking colours are not easy to find and the best can be expensive. The best for steel, for instance, used to be copper sulphate solution, which is not easy for the amateur to get hold of, and over a long time it tends to be corrosive. A good way of colouring steel is to heat it to its tempering colour, brown, purple or blue and leave it to cool. The colour provides an excellent background for scribe marks and will not fade or rub off with time. When the cutting and machining has been done, the normal cleaning up will get rid of the colour.

R.J. Loader

Positioning a machine vice on a milling machine table can be a time consuming operation, even where only a low level of precision is required. This little device will achieve this aim in a matter of seconds for all but the most precise requirements

Positioning a vice on a milling machine table, even to a relatively low level of precision, is an involved operation. It can be what appears as an unnecessarily complex and – even more important – a time-consuming operation.

To position an angle plate all that is necessary is to use a precision square, the bed of which is placed against the edge of the machine table, and the blade against the angle plate face. By adopting this method the angle plate is, within seconds, quite accurately positioned.

The problem

The problem is that normally there is no reference face available on the simple vice, to be used in a similar manner. Consideration was given to providing one, and a method tried but without real success.

The problem of course is that the machine vice faces are remote from the table. The only method is to place a flat plate in the vice, this projecting above the vice jaws, and for it to be tested using a dial test indicator.

For maximum precision this method is the only practical way, but is unnecessarily time consuming when a slightly less accurate result would be acceptable.

The answer

It was considered a requirement to provide some reference face at machine table level, which could be used with a square as in the case of an angle plate. With this in mind the idea illustrated in this article was arrived at. Using the device is identical to that explained for positioning an angle plate and takes only a few seconds longer than just placing and fixing the vice at random.

The design, in principle, would work



The completed positioning device.

A VICE POSITIONING DEVICE

with any machine vice, but the dimensions included in the drawings suit the tilting vice provided with the Drill/Mill to hand, and which appear identical on similar machines. It would, of course, be a wise move to check the dimensions against the vice available, even if it appears to be identical to the one illustrated.

Manufacture

Precise manufacturing details are not included in the article as they are very straightforward; even so the following points are worthy of mention. Initially the parts, particularly the length of the spacers, require to be made accurately, but even with this precaution problems may result.

Due to the remoteness of the two faces, that is the vice jaw and the lower edge of the test plate, minute errors will have a chance of becoming more significant than expected.

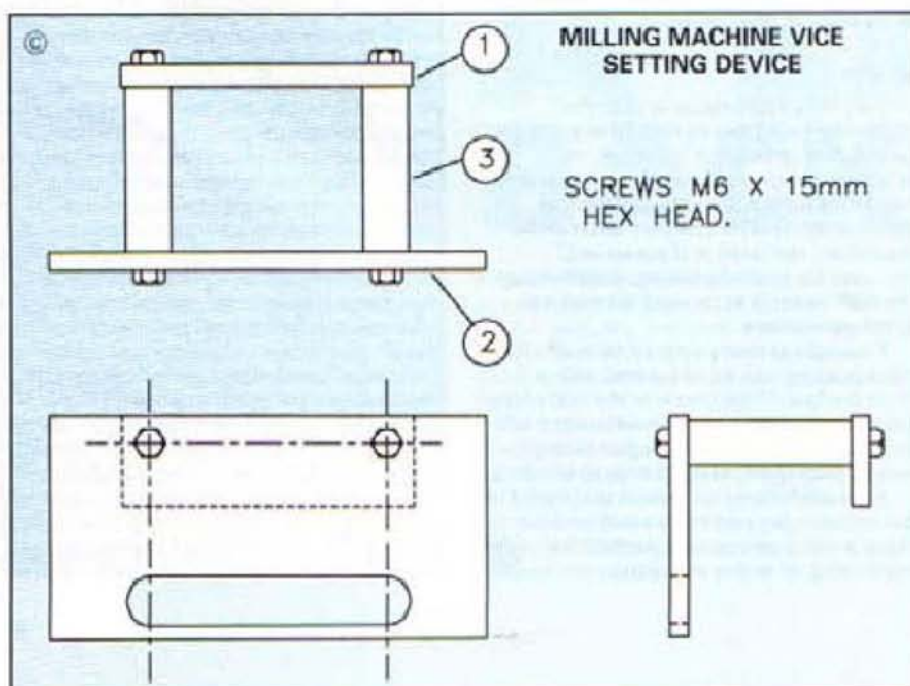
First choose the material (BMS) for the two flat parts and ensure these are reasonably flat; make the parts as is required. The long slot is for easy access to the vice fixing using a flat spanner; it may in some instances be possible to leave this out if sufficient access is available from the side.

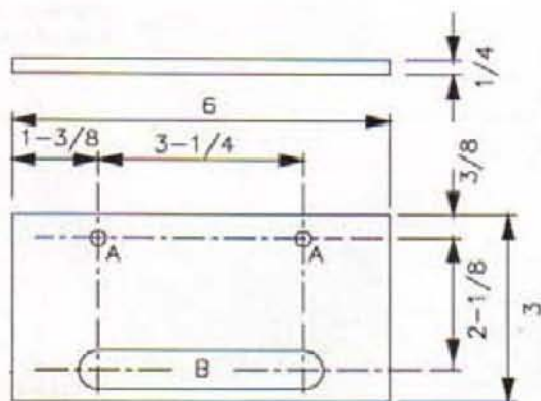
Now with regard to the spacers, it is not unknown, though it may come as a surprise to some, that a spacer turned first on one end then reversed in the chuck and faced again, will end up with faces which are not parallel, particularly with a much used chuck.

Even an error of a few tenths of a thou, will magnify to a few thou, in this assembly. This will particularly be the case if the spacers get positioned with additive errors. Of course this error could be used to advantage during final calibration of the assembly, as an in-built means of adjustment, albeit only by trial and error.

Those who consider the plates chosen are sufficiently flat, may like to adopt the following as a method of arriving at spacers with parallel ends. Place the material in the chuck with, say, a projection of one inch longer than the required length of the spacer, centre drill the end and support with the tailstock centre.

Face the outer end to as small a diameter as the tool and centre will permit, follow this by now producing the other face using a reverse knife tool, leaving about a 1/4 in. diameter spigot between the material in the vice and the spacer being made. By



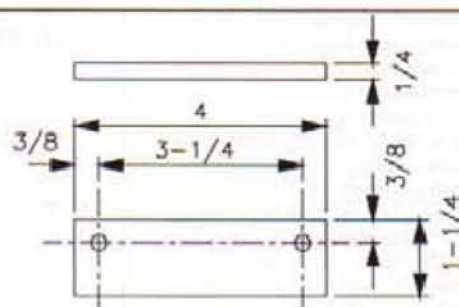


MATERIAL. 3 X 1/4 BRIGHT MILD STEEL.
HOLES. A. 1/4 INCH DIA.
B. 5/8 INCH WIDE SLOT.

TEST PLATE. (2)

ALL DIMENSIONS IN INCHES.

(C)

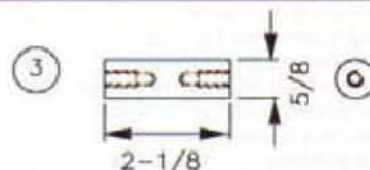


MATERIAL 1-1/4 X 1/4 BRIGHT MILD STEEL.
HOLES. 1/4 INCH DIA.

JAW PLATE. (1)

(C)

SPACERS. (3)



MATERIAL. 5/8 DIA BRIGHT MILD STEEL.
HOLES. BOTH ENDS M6 X 1/2 DEEP.
TWO SPACERS REQUIRED BOTH MUST BE
SAME LENGTH.

(C)

this method the two faces will be parallel. Part off the spacer close to the left hand face, leaving just a short length of the spigot.

The length of the first space will not be critical, but unless at least a vernier is available to measure the second one, this approach would not be worth the additional complication. Preferably a micrometer should be used, but this will necessitate the tailstock being removed from the workpiece to enable the micrometer to be placed in position.

Follow this by drilling and tapping both ends, but without machining the faces. The centre drill can be fed in more than normal to remove any surplus material left by the initial machining stages, providing at least a 1/16 inch rim from the original face is left untouched.

Checking and calibration

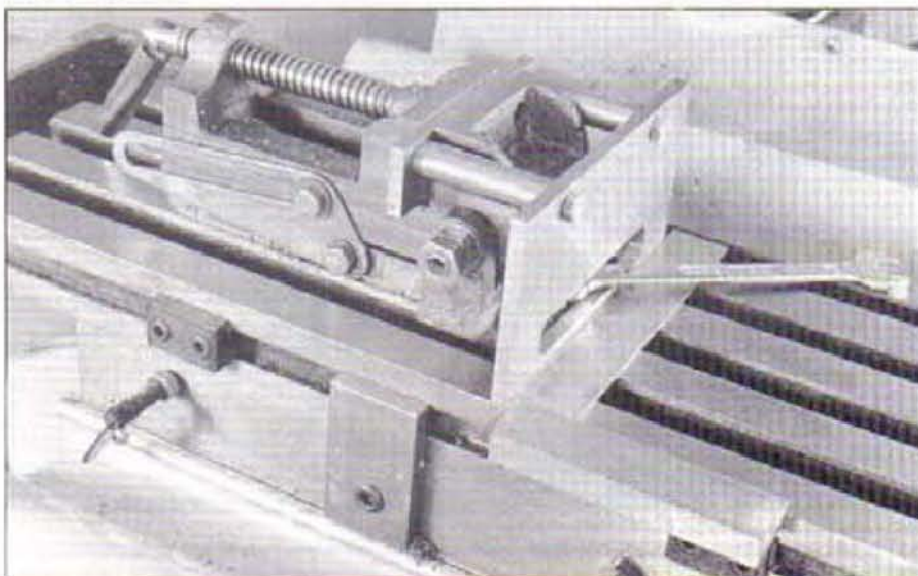
Now assemble the unit, fix in the vice, and set up vice on machine table as indicated in the photograph. Raise the device in the vice and test along the length of the part between the jaws with a dial test indicator. If the result is considered adequate, the project is finished; if an unacceptable error is present, then adjustment can be made as preferred.

If the ends of the spacers are considered to be slightly non-parallel, rotating them could be tried (this worked on the prototype) but this is very much trial and error. Adding shims under one spacer is another possibility - this is probably the most controlled method, but do make sure the spacer is not rotated. Finally the spacer could be removed and returned to the lathe for a small amount to be removed, though this is not so foolproof as it would appear, due to the question of the ends being parallel.

A little time spent on this final operation will provide you with a device that will save a lot of time on future occasions. It will be accurate enough for all but the most demanding applications.



Above: Milling machine set up for slotting the main plate. Below: A vice being positioned using the device.

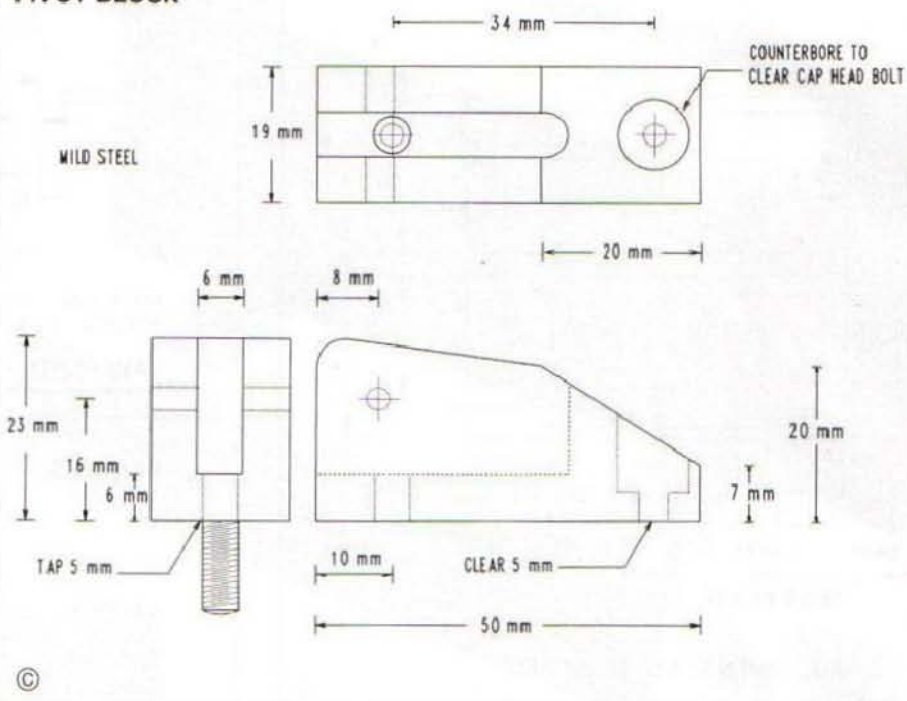


Particularly when drilling small deep holes the standard, screw fed, tailstock is likely to result in excessive force being applied to the drill bit. There is also a tendency to avoid clearing swarf by retracting the drill bit often enough to avoid breakages. A lever feed is more sensitive and enables frequent clearing of the drilled hole. This method of working is for obvious reasons described as 'pecking'.

The device to be described is seen in general arrangement in the photograph. Although designed and built for the Compact 5 lathe the device should be easily adaptable for other small lathes.

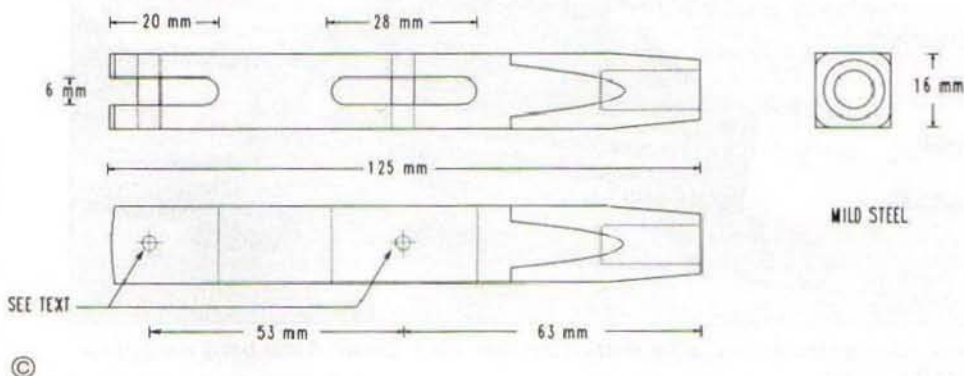
Initially constructors will need to make some decisions. Firstly, which items you may decide to buy as spares. When initially thinking about the project some years ago I had decided to buy in two items: the tailstock casting (Emco Part No. A5A 010 030 - 'Tailstock Housing') and the quill (Emco Part No. A5A 121 000 'Barret metric' or A5B 121 000 'Barret Imperial'). Unless you have access to a larger lathe I would strongly advise purchasing the tailstock casting, boring the hole for the barrel presenting great difficulty. If you want to attempt construction of this part I would suggest fabricating from two or three parts and allowing in the design for adjustment

PIVOT BLOCK



COMPACT FIVE

OPERATING LEVER



and alignment of the tailstock quill with the headstock axis. Note that if you want the fittings for the headstock casting you need to order them separately otherwise you get just the basic casting.

The tailstock quill is a different matter and unless you want a Morse taper bore construction is straight forward. Taper boring the quill will present some difficulties mainly because the headstock bore is too small to admit the quill and maintaining concentricity 170mm from the headstock will cause problems.

I include instructions for making a two part quill utilising a purchased quill. The one part quill will need a thread machining on its end to suit the chuck that the constructor intends to use. A 14mm x 1mm thread to suit Emco accessories is described in the text. As the quill is easily exchangeable a set with alternative ends could be constructed to take alternative chucks.

Construction

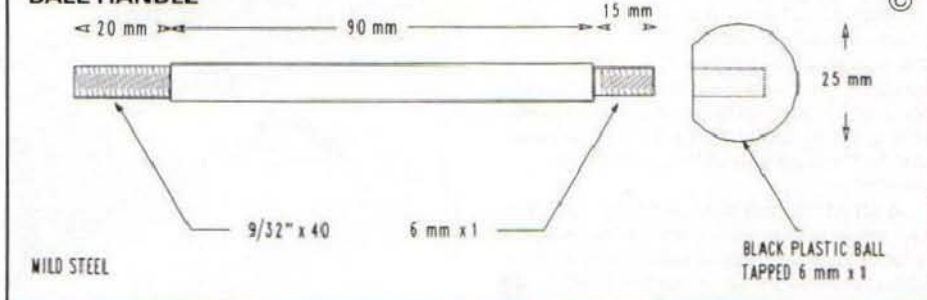
All machining was carried out on a Compact 5 lathe and the Compact 5 drill/mill (fitted to the milling table base rather than the lathe itself). No problem should be found using the mill with the lathe.

Pivot block

For this item a small block of mild steel, 2in. x 1in. x 0.75in., or the metric equivalent is required. I started with a considerably bigger piece when arriving at the final design and reduced half of it to swarf! Start by cleaning up the face that will bolt on to the headstock casting by milling or if a reasonable flat unsawn face is present by filing. On this face carefully mark out and drill the hole for the attachment bolts, the final sizes will be 4.2mm for the tapped hole and 5.0mm for the clearing hole. The holes need not be drilled more than 10mm deep they will be exposed by the final shaping of the block. Then remove the 'missing corner' by sawing.

Shape and clean up the other surfaces by filing, milling or using a combination of the two methods. The next operation is to mill the slot that houses one end of the connecting link. With a relatively lightly constructed mill it is probably wise not to attempt to machine the full width at one pass. Hold the block firmly in a machine vice, use a 4mm end mill cutting 5-6mm deep at each pass, adjust the rate of feed

BALL HANDLE





In this article by John Jennings, he provides us with details to make a lever tailstock for the Compact Five lathe. The design could easily be adapted for other lathes, so if your lathe is not a Compact Five do please still read on . . .

you have the choice of using a 4 jaw chuck or turning between centres; I adopted the latter method. If a 'pip' rather less than 6mm diameter is left this can be used to align the milling of the slots. Additionally you may chose to round off the end in a painless manner, as described in the instructions for machining the quills. Then reverse the job and turn the taper on the other end. It requires about 5 degrees topslide offset giving a 10 degrees included angle. The exact dimensions are not critical but leave a reasonable rim round the tapped hole. Face as much of the tapered end as is accessible (the rest will disappear when the hole is drilled). Finally drill the tapered end 6.5mm and tap $\frac{1}{2}$ in. x 40 TPI.

It remains to mill the slots in a similar way to the slot in the pivot block. Remember when machining the central closed slot that a four flute endmill will not feed vertically as it will ride on the centre pip formed. If you wish to use a mill of this type (rather than a slot drill or 'a one flute across the centre' type) drill a 5mm access hole and feed inwards down this. Again a fairly long reach tool is required. The last process is to machine the pivot holes using the same method you have chosen for the pivot block as discussed above.

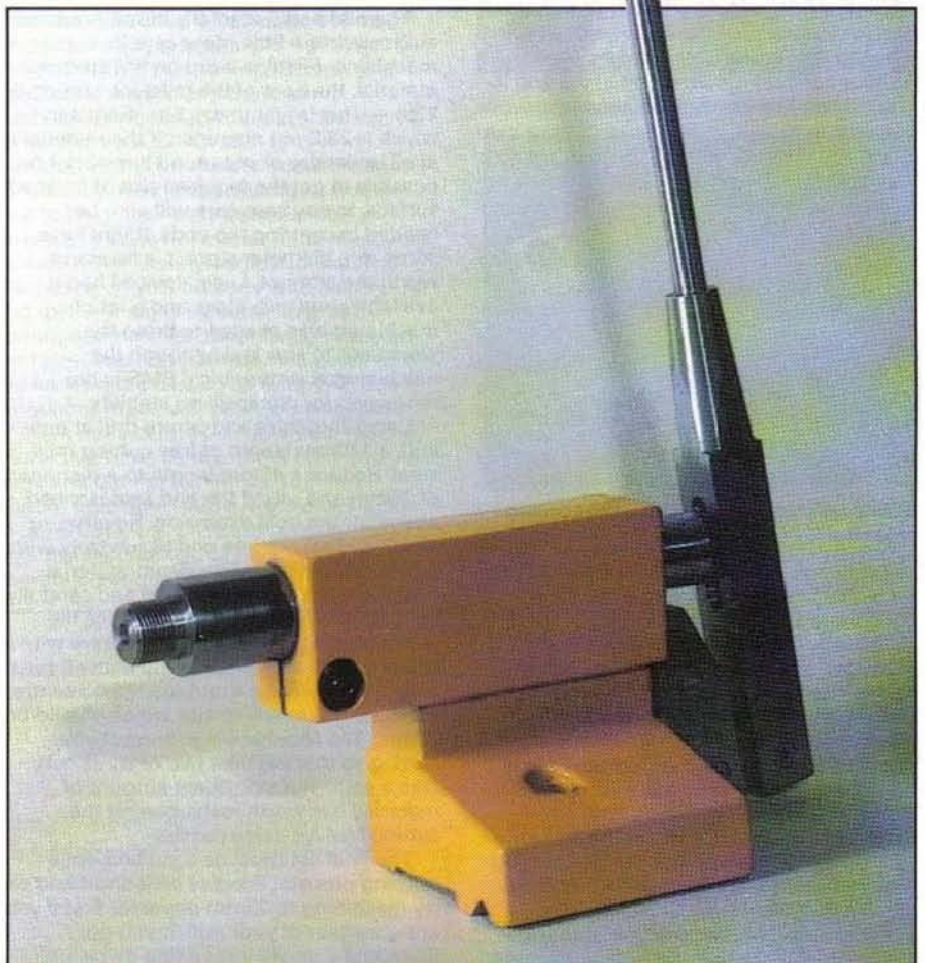
E CONVERSION

so that cutting rather than rubbing takes place; an end mill is not a glorified file! When the full depth is reached, you will need to use an endmill with a long reach to achieve this, open out the slot to the specified 6mm width using light cuts. Use plenty of cutting oil during this operation. Drill the clearance hole right through if the original drilling was not deep enough, and counterbore the recess for the capscrew head. Use your judgment here, it may be neater to reduce the cap head diameter a little rather than use a very oversize end mill. Tap the 4.2mm hole to take a 5mm x 16mm stud cut off a high tensile bolt.

The final job on the block is drilling a hole for the pivot pin. Constructors have a choice here. Well fitted 5mm diameter silver steel pins are the simplest possibility, hardening is probably not necessary. The author used cut down 2BA hexagon socket countersunk bolts. These were selected so that the plain shank provided a 4.75mm diameter bearing surface with the stub of the thread fastening into a tapped hole. The countersunk head was reduced to 7mm diameter to fit the recess that a countersink counterbore that was to hand. As will be seen in the photographs this gives a neat but demountable fastening.

Operating lever

This is made from a 125mm length of square section mild steel, hexagon of similar cross section would be an alternative and indeed was the basis of the initial drawings. After sawing the section to length and cleaning up the ends with a file mark out and centre pip the ends. Centre drill each end and face what will be the untapered end. If using square material



Top, close-up of the lever feed mechanism. Above, a general three-quarter view of the assembled lever feed.



Assembled lever feed and alternative fabricated quill.

Ball handle

This is not a true ball handle of the sort found on classic (and some modern lathes) but is an extension piece with a plastic ball fitted to it! No real instructions are required but choose a reasonably free cutting steel 8mm diameter to ease the screw cutting. The ball is a proprietary item and was tapped 6.0mm ISO. I chose a fine thread for the other end but almost any would do. Within moderation you could make this item a little longer, however too much leverage will enable you to do untold damage!

Two-part (using Emco quill)

If you want to use No.1 Morse taper tooling in your lever feed, the easy solution is to bolt an extension to a spare Emco quill. Since the accuracy is dependent on the proprietary quill the addition needs care rather than exceptional precision. Although the quill is threaded at the end it is a left hand thread and the solution

smaller diameter than the larger part of the barrel. Face the end leaving a pip 5.5mm diameter, to act as a witness when milling the flats on this end. Finally using the leadscrew and cross slide together gently round off the end.

Hold the extension piece in the machine vice and mill off the excess material, the witness pip enables you to determine the amount to be removed. Carefully rotate the workpiece through 180 degrees and repeat the milling process. This machining should give you a tab about 5.4mm thick which will allow for a thin phosphor bronze washer each side.

Finally mark out and drill the hole to size for the pivot pin you have chosen.

One part quill

The one part (i.e. totally home produced) quill requires a little more care in machining. Firstly a word on the starting material, the bore of the tailstock casting is 22mm. This is just under $\frac{1}{2}$ in. diameter which is 22.2mm diameter. If the material is at all undersize or not round it may not be possible to get the required size of finished surface. In any case care will also be needed in centring the ends. If you have some $\frac{1}{2}$ in. diameter stock it is however worth the attempt, I used (since I had it available) one inch stock and a lot of machining was needed to bring the workpiece to size and although the machining is symmetrical BMS is not renowned for dimensional stability.

Carefully centre and centre drill at one end, a 170mm length of free cutting mild steel. Reduce a 45mm length to a diameter of 18mm and round the end as described above for the quill extension. Reverse, re-chuck and set the free end to run truly with a dial indicator (if using 25mm material centring each end will suffice) and carefully centre drill. Using a half-centre face the exposed end. Replace the half-centre with a rotating centre (providing you know it runs truly otherwise use a carbide tipped centre. Machine accurately to size which should be 22mm. The trick here is to control your cutting so that the final two or three cuts take a small but significant amount of material, it is worth sharpening the cutting tool for these passes.

The final cut must be a cut and not a rubbing process. Practise on a short end or try machining to 23mm diameter first if you are uncertain of your skill. If you go undersize you will have a fine piece for scrap box and if using 25mm stock a whole heap of swarf. Without removing the quill from the lathe you should now machine

the end of the quill to give the chuck fitting that you need. I chose a 14mm x 1mm nose thread, which is used for fittings on the Unimat 3 and Compact 5 lathes, which enabled me to fit drill, collet and 3 jaw chucks. Carefully turn down a 10mm length to 14mm diameter again ensuring that the final amount is removed with a proper cut. Set up for screw cutting a 1mm thread and carefully align the screw cutting tool for centre height and squareness. With a short thread like this you will need to turn the workpiece by hand, a mandrel handle (I described one in *Model Engineer* No. 3710 August 1983, page 153), (Copies of this article are available price £1.50 UK, £2 overseas. Ed) is ideal but for a short length of thread turning the motor pulley - after disconnecting power - will suffice.

On lathes such as the Compact 5 that have a solid lead screw nut the return pass is accomplished by reversing the direction of rotation. Before you can do this you



Details of part-assembled tailstock.



Milled tailstock and small parts including pivot bolts.

adopted was to use a 6mm high tensile cap screw, which fits neatly into the bore, bolted into the extension piece.

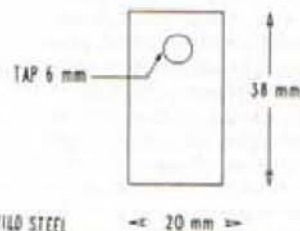
Chuck a 75mm length of free-cutting mild steel and adjust to run truly, if you have a fixed steady support the workpiece at the free end. Centre drill, remove the fixed steady, replacing it with a centre and skim the accessible part of the work piece. Refit the fixed steady and then drill in stages to a diameter of 5mm and 30mm deep. Face the end. Open out the end to 10mm with an endmill or D bit. Then using a sharp boring tool open out further to fit the end of the quill you are using, this dimension will probably be just under 12mm, make sure that this widened part is 10mm deep. Reverse the workpiece and re-chuck, skim off the unmachined part, reducing 20mm of the length to a slightly

OVERSIZE WASHER



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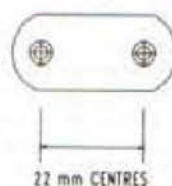
RETAINING TAB



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LINK

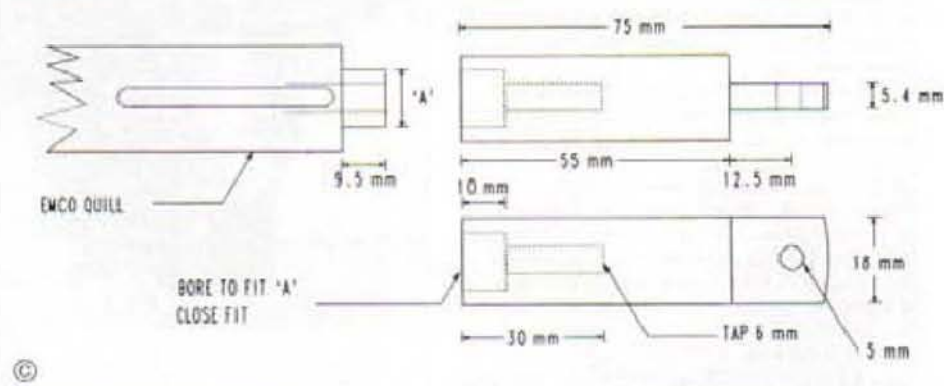
6 mm OR 1/4" WED CARBON STEEL



©

must retract the cutting tool, having noted the setting, as even slight back lash will cause the tool rub and degrade the forming thread. Continue cutting using ample cutting oil, until the full depth of thread is achieved. You should leave about 2mm unthreaded to act as a register. I left the thread very slightly over size and finished the thread with a die and thread cutting paste to a firm fit on the accessories that were to be used. It is worthwhile if you have the time to determine what the exact nose size is required for each accessory and how far a split die needs opening to size accurately – the die I used needed opening as far as the die holder permitted if it was not to cut undersize – which at this stage would have been a disaster. Best practice is of course to mount precision

FABRICATED HULL



Assembled lever and one and two-piece quills.

drill chucks on Jacobs taper stubs, if you want to attempt this you will need to turn between centres so that it is possible to remove the quill and check the taper checked with engineers blue against the socket in the drill chuck. The stages of machining to form the tab to take the pivot pin is identical to that of the composite quill described above.

The final operation is machining the slot that restricts the movement of the quill. Firmly mount the quill in a machine vice on the milling machine table gripping it at the section that is to be slotted. Make sure that the pivot tab is vertical before machining the slot 4mm wide and 3mm deep. With a very fine file remove the sharp edge and any raised swarf left by machining the slot.

If you want to add graduations I suggest that you copy the method used on the standard quill, that is to cut a slot and in this fit a small piece of rule.

Machining the tailstock casting

Due to its method of production the face of the right hand end is not flat (i.e. right hand when on the lathe in normal

position). To bolt the pivot block firmly and accurately it is necessary to skim over part of this surface. Grip the casting in the machine vice, use a small piece of firm cardboard each side to avoid marking the paintwork, this gives a firm enough grip if light cuts are used and the method I intended using of fastening the casting, via its bore, onto a 22mm stud is over elaborate. Remove the minimum amount of metal by setting the casting so that the face to be machined is as horizontal as possible, it does not matter if the machined surface is not exactly vertical in use. The machining should be done with a sharp end mill or a small fly cutter to give two rectangular patches 20mm wide to accept the fastenings. Do not machine down to the neck on the casting as removing this amount of metal will seriously weaken it.

Mark out a centre line down the casting, aligned with the centre of the bore and mark and pip the two holes. Drill the bottom hole 5mm and the top one 4.2mm to tap 5mm x 1 in this case continue drilling until the second web of the casting is penetrated about 25mm deep. This will

QUICK TIP

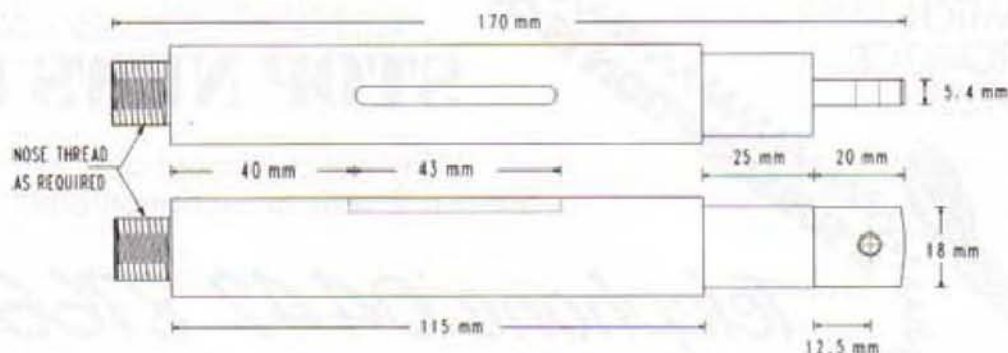
One often sees old drill chucks, ex DIY electric drills for sale very cheaply on junk stalls at markets, boot sales, etc. Often we pass these by as being of no value to us, the threaded shank will not come out easily and one cannot guarantee the accuracy of the chuck even if one went to the trouble of boring it for a standard taper shank. However, all is not lost! Buy one, identify the thread, and tap a small rectangular block of steel to suit. Screw in the chuck, with a little Loctite to secure it, and one now has an excellent piece of auxiliary tooling for the vice. The three jaws will hold all manner of small round objects – screws for slotting, rods for tapping, in fact the uses are endless.

allow the fastening cap screw to share the load it imposes on the casting. You may prefer to 'fit' the pivot block by completing the tapped hole, bolting the block in place, and using it as a jig to drill the 5mm hole.

Odd bits

These are also straightforward items. The link should be made of something better than mild steel, medium carbon steel, or gauge plate should suit. Adjust the thickness to fit the slots in the operating lever and pivot block. Hardening is not required. The oversize washer is intended to spread the load inside the tailstock casting, light alloy will allow it to bed down. The retaining tab, is a replica of the one you have already got. It is more convenient if the lever and regular tailstock have their own.

ONE-PIECE QUILL



Assembly

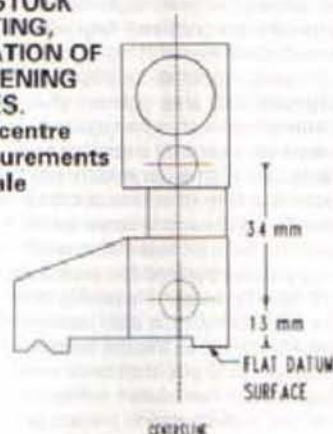
Clean all the constituent parts, removing all swarf or grit which will cause havoc in the casting bore. Finish with a wipe with a clean oily rag.

Check the fit of the quill in the tailstock bore, a little oil will ease access if you have a good fit. Fit the retaining set screw (this is 6mm x 1 with a 3.5mm peg turned on one end - copy the one in your standard tailstock) this will prevent the quill falling out under its own weight. Fasten a 20mm stud into the tapped hole in the pivot block using Loctite. Bolt on the pivot block using a 25mm long cap screw and then complete the lower fastening with the oversize square washer and an oversize nut. Mine was about 11mm AF tapped 5mm. Fasten the link into the pivot block by the chosen method and then attach the lower part of the operating lever. Space the quill from

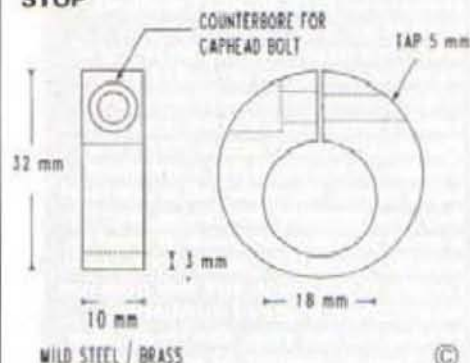


Facing the head of the tailstock casting.

TAILSTOCK CASTING, LOCATION OF FASTENING HOLES.
Only centre measurements to scale



DEPTH STOP



the operating lever with a phosphor bronze washer each side of the tab. Cut these washers from strip or part off from a drilled bar. Fit the extension lever.

Try the action of the lever feed and after a little gentle bedding in it should operate smoothly. Fit your chuck and try out on the lathe.

Depth stop

The original drawings did not include a depth stop. A suggested design is shown in the drawing. Cut off and machine both faces of a 10mm slice of 32mm free cutting mild steel or brass. Chuck in a 4 Jaw independent chuck with a 4mm offset in one direction. Provide rear clearance by using a 2-3mm scrap (plastic or wood would do) spacer a little smaller than the

blank or use removable spacers while tightening the chuck jaws. Drill through and open out until you can get a small boring tool into the hole. Bore out to fit the quill extension or the narrow part of the one part quill. If you are intending to use the depth stop with the one part quill you will probably need to machine down another 10-15mm of the quill to 18mm diameter. To some extent this conflicts with the original design which tried to keep the tailstock bore 'full' of quill over a larger range than the standard arrangement. The final bore should enable an easy sliding fit on the quill. Firm clamping is achieved by drilling and counter boring for a 5mm cap screw and finally slitting with a hacksaw or slitting saw opposite the narrowest part.

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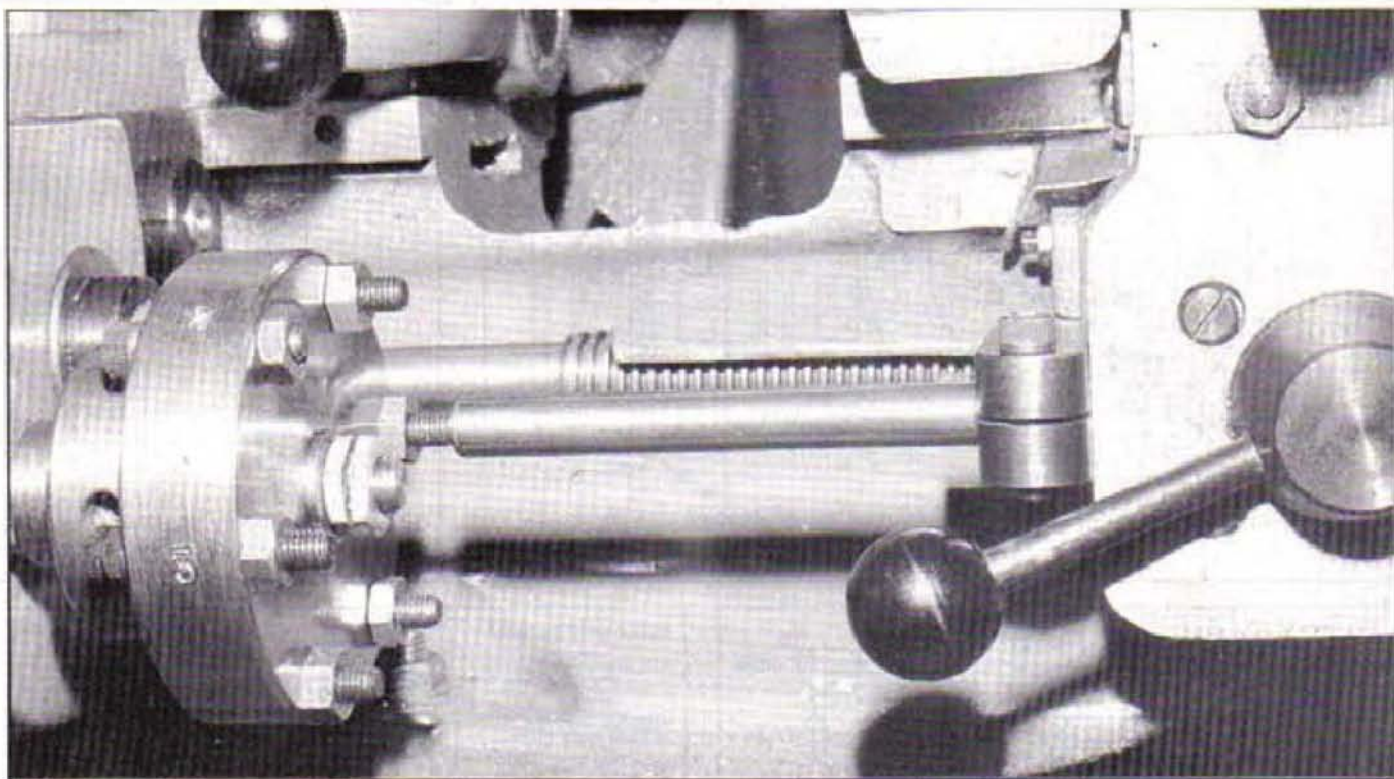
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Saddle stop in holder engaging with threaded stop on turret. (Sharp-eyed readers may notice that socket capped screws have been used for the threaded stops in the turret; these are temporary and will be replaced by studding in the near future.)

A SIX-STATION SADDLE STOP

This saddle stop was designed to fit the Myford Super 7B (power crossfeed model); owners of early Myfords may have to make some modifications. It is simple to make and was fitted without drilling any holes in the machine.

Anyone who has used an industrial lathe fitted with a multi-position saddle stop will know how much easier it is to machine a batch of components, without having to constantly stop the machine to check dimensions, it only being necessary to engage the required stop and work to your index readings.

When a project came up requiring many repetitive parts it was decided a multi-station saddle stop had to be made. But where to position it? I wanted it close to hand, and fitted without drilling holes in the lathe. The best position seemed to be on the end of the gearbox but there were no conveniently tapped holes here, except the gearbox oil level plug. The plug was removed and found to be 0.312 BSF. I decided to use the hole for mounting the stop turret assembly, it being no more trouble to remove the stop to check oil level than the plug.

Having established the position of the turret, I now needed another convenient hole on the side of the saddle for the stop holder. On investigation another 0.312 BSF hole was found on the side of the saddle; this hole contains a grub screw which retains the self act lever. When the screw is at its correct depth for holding the lever

This six station saddle stop, by C J Vickery of Torquay, will considerably ease the production of batches of identical components. When involved in second operation batch work, it will also benefit by the addition of the backstop described elsewhere in this issue

there is some $\frac{1}{8}$ inch of thread left above it, just enough to hold a screw for the stop holder.

The index plate

Start construction with the index plate. This was cut from a sheet of $\frac{1}{8}$ inch gauge plate. Coat with marking blue, centre pop, draw a 2 in. dia. circle, drill and ream $\frac{1}{8}$ in. dia., then cut out the 2 in. dia. circle roughly with a hacksaw. Now turn up a $\frac{1}{8}$ in. dia. screwed mandrel in the lathe, mount the plate on it and turn to 2 in. dia. The holes can now be marked out. This is best done in the lathe. If no dividing equipment is available, the chuck jaws can be used for dividing. Clamp a piece of steel bar in the tool post with about $1\frac{1}{2}$ in. protruding; wind the crossslide in until the steel bar is in contact with one of the chuck jaws. Set a scribing block to lathe centre height then, keeping the chuck jaw in contact with the steel bar, scribe a line across the index plate. Now without moving the crossslide wind back the saddle, rotate the chuck to bring the second jaw in contact with the steel bar, and repeat the operation. Then on to third jaw until all the lines have been scribed. The hole P.C.D.s could be marked out by clamping a screwcutting tool on its

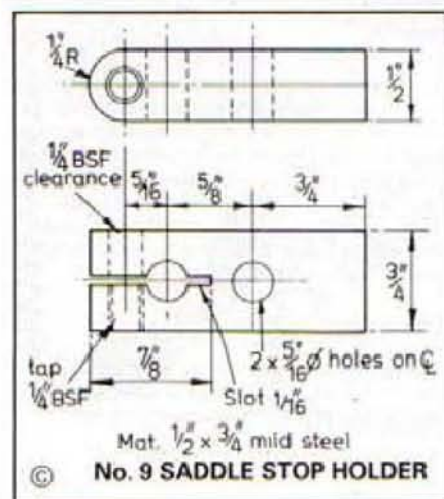
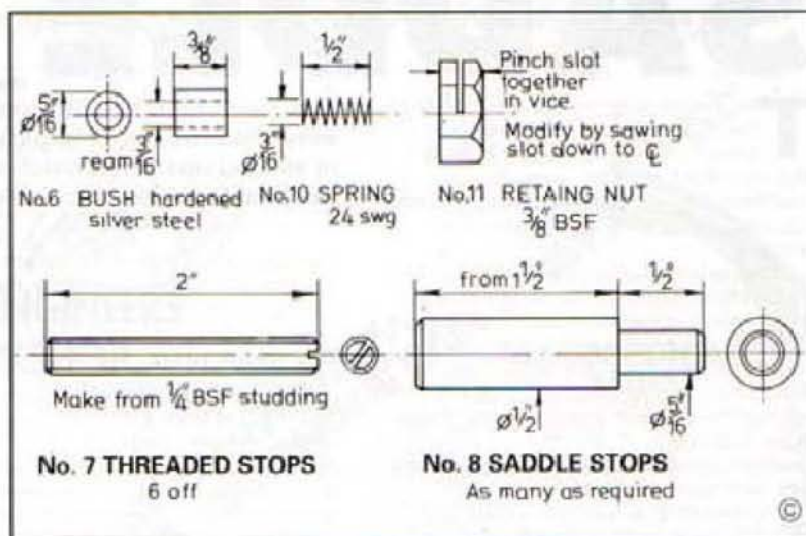
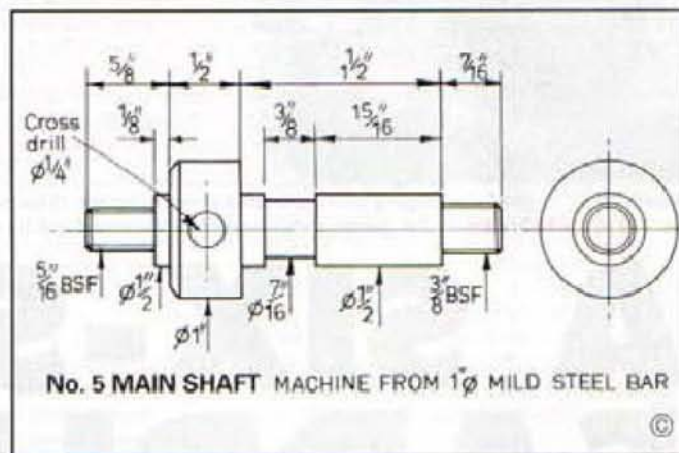
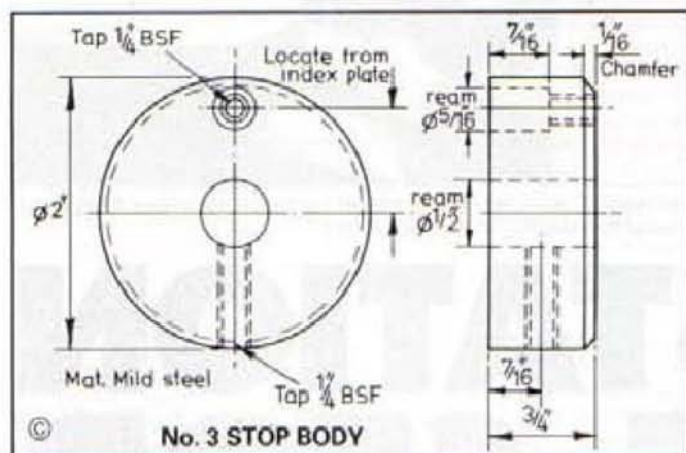
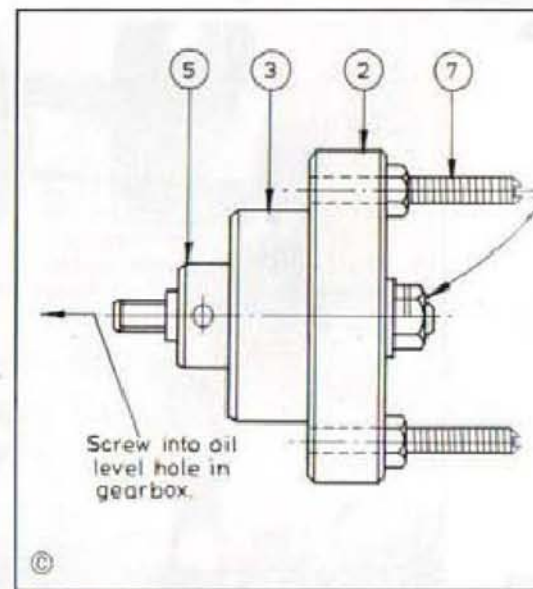
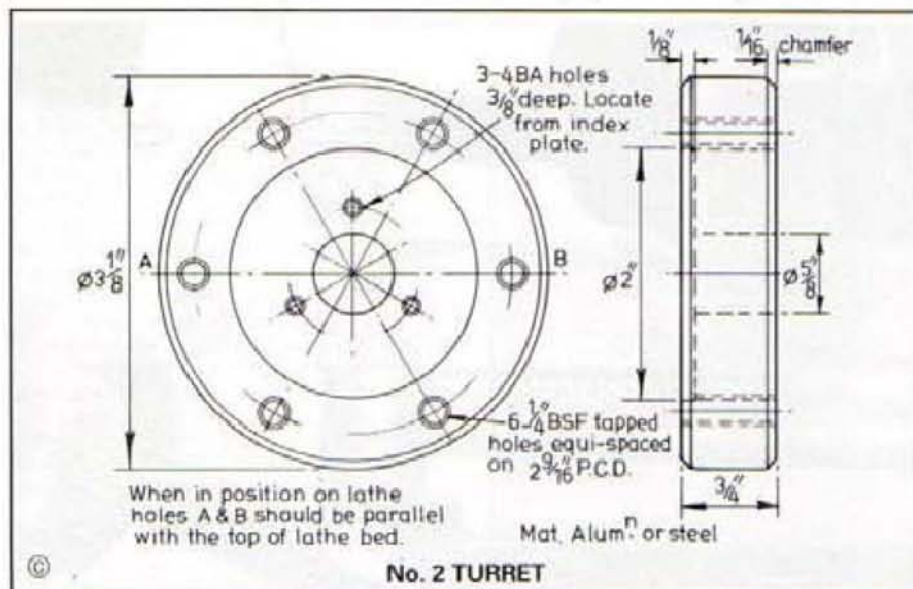
side in the toolpost, and with the crossslide set in the correct position, turn them in just a few thou. deep. The plate can now be removed from the lathe and all the holes drilled. The three 4BA clearance holes should not be countersunk at this stage.

The turret

Mine was made from mild steel but aluminium would do just as well. The $\frac{1}{8}$ in. dia. hole and the 2 in. dia. register for the index plate should run concentric with one another so should be turned at the same time. Use the index plate as a gauge when machining the register. The holes can be marked out using the same method as the index plate. The index plate should now be inserted into the register, its holes lined up with the $\frac{1}{8}$ in. tapped holes in the turret. The three 4BA holes can now be spotted through. The 4BA clearance holes in the index plate can now be countersunk and the plate hardened. Do this by heating to cherry red, then quenching out in oil.

The body

This was turned from an off-cut of 2 in. dia. mild steel bar. The 0.312 dia. hole for the hardened bush is spotted onto the



body through the index plate. To do this you will need the 1/16 in. dia. bore bronze bush, so machine one up, then temporarily press it into the index plate. The hole can now be spotted in by using a piece of 1/16 in. dia. rod to locate the body to the index plate. Drill and ream, 0.312 dia x 0.437 deep, then drill through the rest of the way and tap 1/4 BSF. Don't forget the tapped hole in the side of the body. Make up the hardened bush from silver steel, then press it into the 0.312 reamed hole, e.

The main shaft

This is machined from 1 in. dia. mild steel bar. Before screwcutting the 0.312 BSF thread, remove the oil level plug from

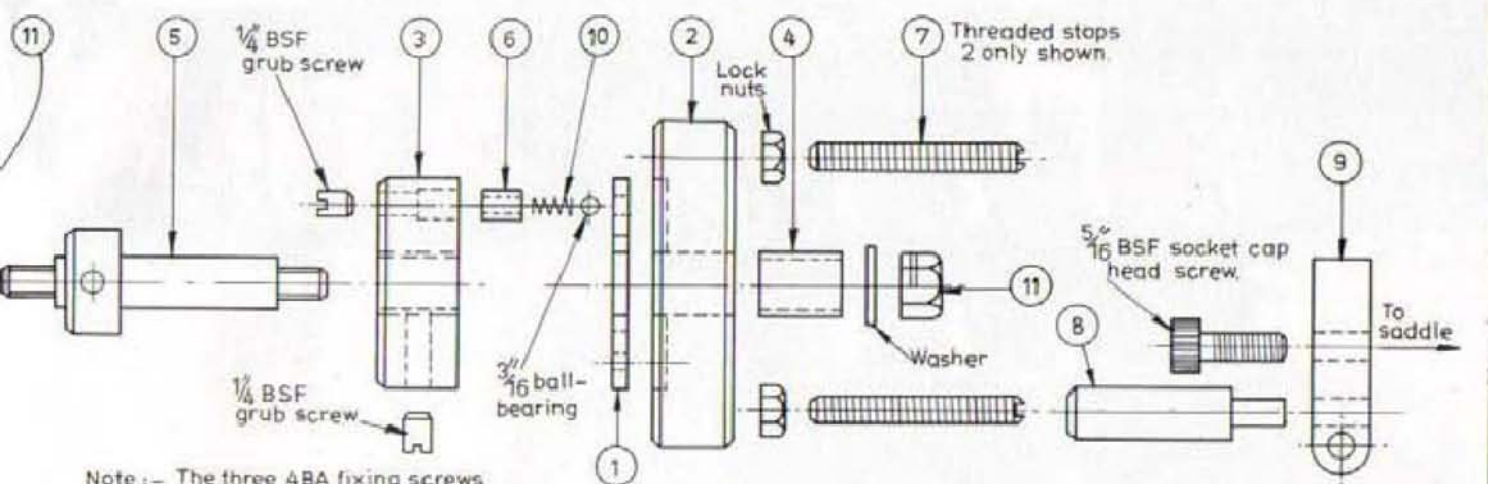
the gearbox on your lathe and check it as Myford may now be using metric threads on their later machines. The 1/16 in. dia. crosshole is for a tommy bar for tightening, when screwing into the gear box.

Threaded stops

1/4 in. BSF Studding was used for these; each end was faced and chamfered, then a slot cut in the end for a screw-driver.

Saddle stops

I turned these from 1/16 in. dia. steel bar. Mine start at 1 1/16 in. height and go to 4 1/16 in. rising in 1 in. increments, but of course you should machine yours to suit your own requirements.



Note:— The three 4BA fixing screws for index plate are not shown.

GENERAL ARRANGEMENT AND ASSEMBLY

Saddle stop holder

This was cut and filed up from 1/8in. x 1/4in. steel bar; the slot was put in with a 0.062 slitting saw.

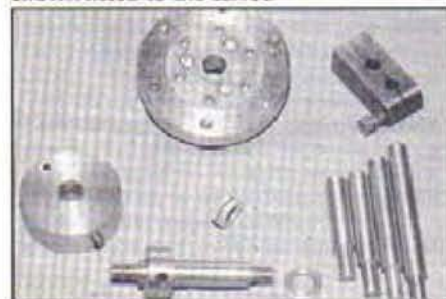
Assembly

Secure the index plate to the turret with three 4BA countersunk screws, press in the bronze bush. Now start assembling the parts onto the main shaft starting with body; push this down hard against the shoulder on the main shaft, then nip up the grub screw in the side of the body to secure it to shaft. Slide on the turret, index plate first, not forgetting a smear of grease on shaft. The turret is held with a washer and a lock nut, I used an ordinary nut converted into a locking type by making a saw-cut on the side of the nut down to its centre line, then squeezing the slot together in the vice. I find this works well and is much more compact than the commercial Nylok type.

Tighten the nut so that the turret can rotate freely but without end-float. Drop a 0.187 dia. ball bearing into the hardened bush, followed by a 0.187 x 1/4in spring, then secure with 1/4 BSF grub screw. Now screw the whole assembly into the oil level hole on the end of the gearbox, using a tommy bar in the 1/4 crosshole to tighten. When tight, slacken the grub screw in side of body — the body together with the turret can now be rotated to bring it into its correct position.

This is correct when holes A & B are parallel with the top of the lathe bed (see turret drawing). Screw the six threaded stops into the turret using 1/4 BSF nuts for locking them. The saddle stop holder is now positioned on the saddle so that the stop lines up with hole in turret. If your lathe has the 0.312 tapped hole, just one 0.312 BSF screw is all that is required to secure the holder to the saddle. If not, one will have to be drilled and tapped.

The component parts; the index plate is shown fitted to the turret.



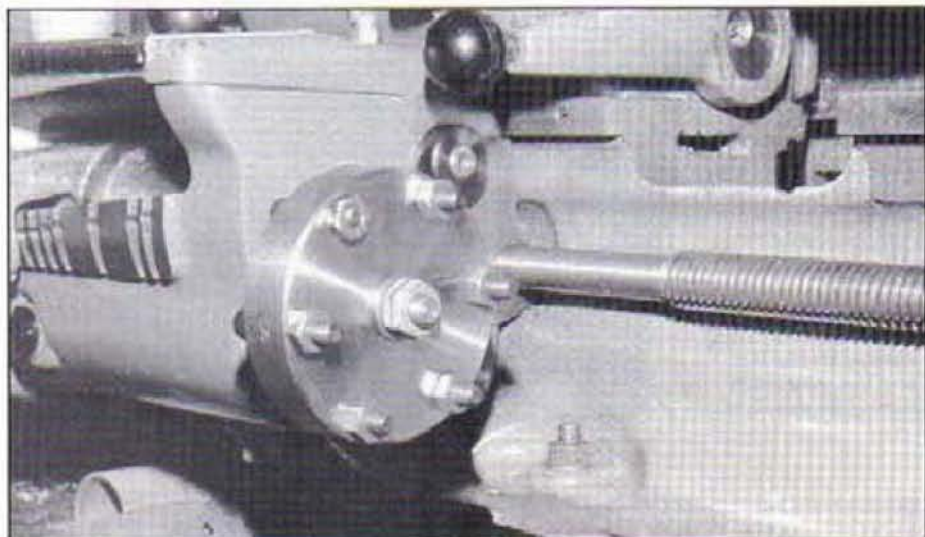
Using the stop

I don't think many model engineers will need telling how to use the stop, it's just a matter of selecting the right length of saddle stop for the job in hand, clamping into the saddle holder then adjusting the threaded stop pins on the turret to suit each machining stage. Each of the stations on the turret should be numbered and, when machining the next component, the same stations should be used and also the same cross-slide index reading for each

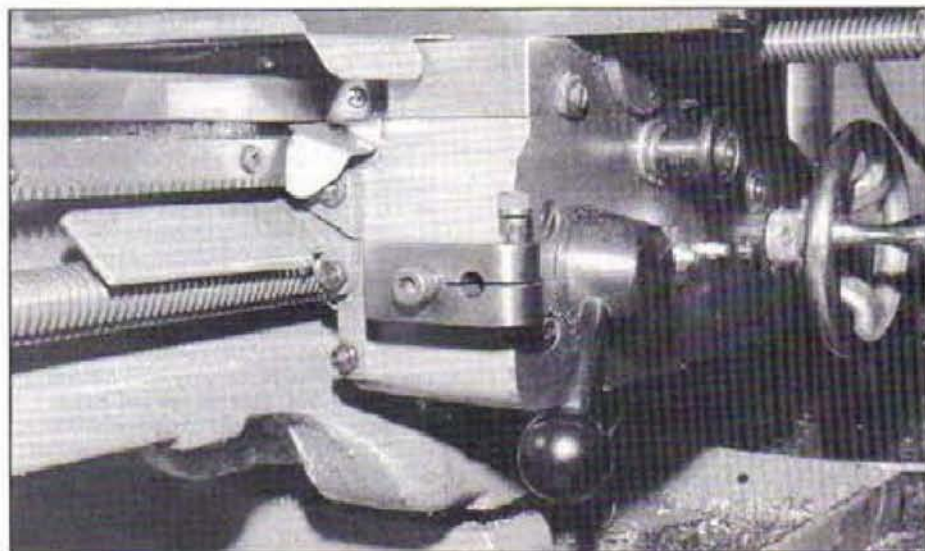
operation should be remembered. Then, if everything has gone to plan, the next component should be the same as the first.

One note of caution; when working close to the spindle nose with collets or face-plate, using self-act or screw-cutting, care should be taken not to run the self-act lever into the stop.

Well, I hope you will find this stop as useful as I have; it certainly takes the hassle out of repetition jobs and, for the amount of work involved in making it, I found it was very worthwhile.



Above, the turret in position on the gearbox. Below, saddle stop holder in position on saddle.



For any reader interested in gaining more knowledge on this subject, a very useful book *Electric Motors* by Jim Cox, is available from Argus Books price £6.95 plus 70p, p&p.

START



The main internal components of the Crabtree CEICON starter, the upper component being the contactor and the lower one the overload. Note the adjustment for current on the left and the reset/stop button on the right.

The third in a short series of articles on electricity in the home workshop by Chris Boucher F.I.E.E. This time he discusses motor starters and the types of motors suitable for running machine tools

In the previous two articles (see *MEW* Dec/Jan '92 and Feb/Mar '92), brief reference was made to motor starters. This is an area of electrical safety often overlooked and this short contribution looks in more detail at the purpose of motor starters. At the same time, the various types of motor suitable for running machine tools are also described. Readers who purchase surplus industrial equipment fitted with three phase motors who are faced with the task of converting them to single phase will be particularly interested.

Single phase

All motors for machine tools should have a starter (commonly called a 'Direct in Line' starter) as a control. Not only does this act as a switch, but it has at least two other functions:-

1. To provide a means of switching off the power in the event of a mechanical or electrical emergency and isolating the circuit. The off button is coloured red and is a quick action push switch isolating both live and neutral.

2. To provide a thermal overload circuit which will switch the current off in the event of the rated value being exceeded.

There is a third function which should ideally be built into the starter and that is an electromagnetic contactor, which will break the circuit in the event of voltage drop or supply failure, thus preventing automatic restarting when the supply is reconnected. This is in fact an IEE safety requirement when danger could occur and is certainly recommended for all machine tool applications. These starters are known as 'no voltage release types' and their operation can be fully understood by following through the circuit diagrams with this article.

The circuit diagrams included in this article, are for the Crabtree Electrical Industries Ltd CEICON range of starters - there will, though, be very little difference between modern starters of any make.

The unit will consist of two separate circuit functions, one is the power circuit which will switch and monitor the current being taken by the motor, the other being



A complete direct on-line, no volt release starter - another from the Crabtree CEICON range.

the control circuit which can be seen in Fig. 1. For those not familiar with this type of circuit the following is a brief explanation.

The component parts of the circuit are as follows:

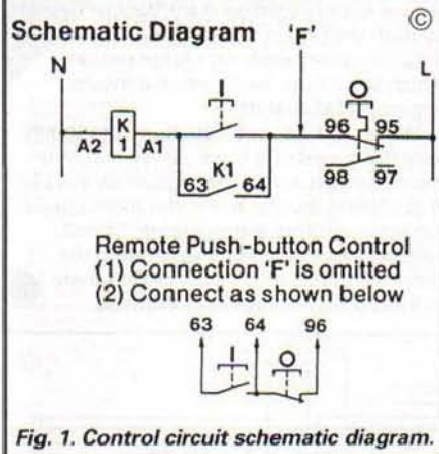
The rectangle marked K1 is the operating coil for the contactor.

A contact on this contactor is included having terminal numbers 63 and 64, this is a normally open contact. This indicates that it is open when the coil on K1 is de-energised and will close when energised.

The start push button is included and is labelled I, this now being the international

ERS & MOTORS

FOR MACHINE TOOLS



standard symbol for 'start' or 'on', when applied to push buttons or switches. This is frequently now seen on domestic equipment.

The contact with terminal numbers 95 and 96 is the trip contact fitted in the overload relay. Normally in larger systems there would be a separate stop push button. It is though common practice in these small starters to make it possible for the contact in the overload relay to be operated manually from the stop push button. This is mounted on the front of the enclosure, thus giving the contact a dual function. For this reason the contact on the diagram is also marked with the standard stop symbol 'O'.

The contact with terminal numbers 97 and 98 are spare contacts on the overload relay.

Control of the motor is achieved as follows. With the start button I pressed, the contact will close and complete the circuit between L and N via contact 95, 96, the start push button and the coil A1, A2, thus energising the contactor K1.

With the contactor energised, contact K1 63, 64 will close and the circuit will then be maintained through 95, 96 to 64, 63 to coil A1, A2. Therefore, even when the start button is released, the contactor will remain energised.

To release the contactor and stop the motor, contact 95, 96 must be open; this will happen if the stop button is pressed. Also being the trip contact in the overload relay, it will open if the motor is overloaded.

With the stop contact opened, even momentarily, the contactor will be de-energised and the contact 64, 63 will open thus ensuring that the start push button will require to be pressed again to restart the motor.

In the case of a power supply failure the contactor will similarly de-energise, and will require the start button to be pressed again, hence the term No Volt Release.

It will not be the case often that push buttons remote from the starter are required, but if required the additional push buttons can be added as indicated in **Fig. 1**. When being used to control a large drilling machine, a foot operated stop button would be a desirable safety feature.



Single phase capacitor start induction motor; note rubber anti-vibration mounting next to the pulley.



Built for heavy use. Three phase induction motor; although this motor looks old, it performs well and the bearings are in excellent shape. Note plate giving all the running details

It is not essential that both remote start and stop buttons are added, and in this case only the foot operated stop button could be added into the circuit at F as indicated.

The overload relay is operated by a bimetallic mechanism heated by the motor current. This will take time to cool, and it will therefore be impossible to restart the motor before a time period has elapsed. The delay will thus give the motor time to partially cool.

The overload relay requires to be set accurately to motor full load current and this value should be found on the motor data plate. The range of current covered by a particular overload is quite narrow, there are 13 overloads in the CEICON range to cover from 0.1 amps through to 18 amps. Do take care not to end up with the wrong item ...

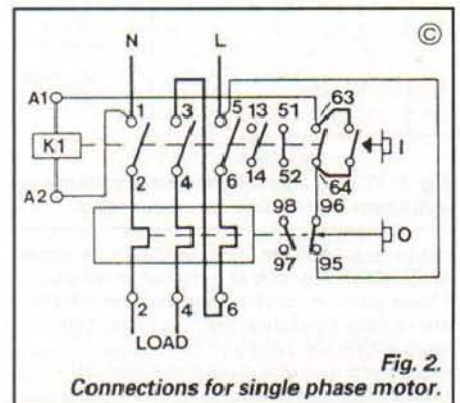
If a manufacturer's chart lists both HP/KW and current ratings for their overloads, the power figures should be considered approximate; choose the overload only by reference to the current figure quoted on the motor nameplate.



Single phase series wound commutator motor; this type can be recognised by the clearly visible commutator/brushes.

When purchasing a starter, in addition to specifying the motor current it is essential to quote the coil voltage, ie 240v 50Hz for single phase or 415v 50Hz for three phase (or as appropriate for readers outside the UK. Ed.). By far the majority of these starters will be supplied for 415v, and if 240v is the required value but not quoted, an unsuspecting supplier would probably supply a starter for 415v.

Because single phase starters are a rarity overloads are only made for three phase use, this is not a great problem but for reasons too involved to go into in this article, current must pass through each overload heater. It can be seen in **Fig. 2** that, to achieve this, the Line connection 'L' is arranged to pass through two poles of the contactor and overload. This will require to be done when being installed, the data supplied with the starter will though cover this requirement in detail.



Types of motor

What types of motor are used for machine tools? By far the most common type of single phase motor is the induction type with a capacitor start. The smallest size that should be used for a reasonably sized model engineer's lathe, for instance is ½ H.P. but this type of motor is available up to about 3 H.P. If you are looking for a secondhand one, they can be recognised



Starter on the author's three phase drill; note emergency stop button located near handwheel for easy access.

by the capacitor which is usually mounted on the motor casting (see photograph). All motors should have a stamped plate on them giving their rating. For instance, a 1/2 H.P. motor would probably be marked: 240 volts 1 phase 370 watts 50 cycles 3.0 amp.

Although ideal for many workshop purposes these motors do suffer from a number of disadvantages. They are synchronised to the mains frequency and are therefore single speed (usually about 1500 rpm), they suffer from vibration and are not self starting. The single speed problem can be overcome by the use of suitable step down pulleys and a gearbox where necessary. The vibration problem is dealt with by mounting the motor on rubber pads or some other shock-absorbing material and indeed most motors will be supplied with this in place. The one in the photograph has rubber mountings round both bearing spindles.

The capacitor is provided to start the motor and **figure 5** shows the circuit arrangement. The auxiliary winding with the capacitor in series provides a temporary second phase which enables the motor to start. The switch is in fact a centrifugal one mounted on the rotor and it opens when the motor approaches running speed. The other commonly available type of single phase motor which is readily available is the series wound commutator/brush one. These are often used in washing machines. They are self-

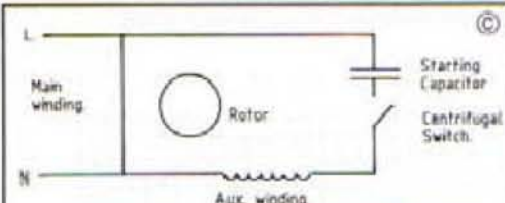


Fig. 5. Wiring diagram of a single phase induction motor with capacitor start.

starting, smooth running and can be varied in speed by the use of a thyristor control. These are similar to light dimmers which are readily available, but it is important to ensure that the rating of the motor expressed in watts does not exceed the rating of the control.

From the above description one could assume that this type of motor would be ideal for the workshop, but unfortunately they suffer from one serious disadvantage. They are designed to run at a very high speed, but this decreases rapidly as torque (load) is increased. If, for instance, a motor of this type was connected to a lathe there would be a very significant decrease in speed with a heavy cut or when parting off. The main practical application in the workshop is therefore likely to be in

grinding, where this characteristic does not matter. Although in theory, it should be possible to reverse both these types of single phase motors by changing the position of or reversing the windings in the field/auxiliary coils, this should never be attempted unless the motor has been designed with this in mind, and when using single phase motors it is best to devise a mechanical means of reversing when two directions of rotation are required.

Three phase

For any model engineer who has connected a three phase supply in the workshop, by any of the means described in the last issue, the problem of motor selection is a much easier one to solve. Three phase induction motors are self-

The voltage in the controlled phase increases to full voltage over a predetermined time, which can be varied. The starting torque is limited, which in turn reduces the stress on the transmission components. Soft starters must not be confused with reduced voltage starters to reduce supply voltage disturbances caused by high starting currents. Such devices are only necessary with very large motors which would not be found in a model engineers' workshop.

Whilst it is not possible to continuously vary the speed of a three phase induction motor (unless a variable frequency supply is available), two or even four fixed speed induction motors are available. Speed variation is achieved by separating the stator windings and reconnecting them to form different numbers of poles.

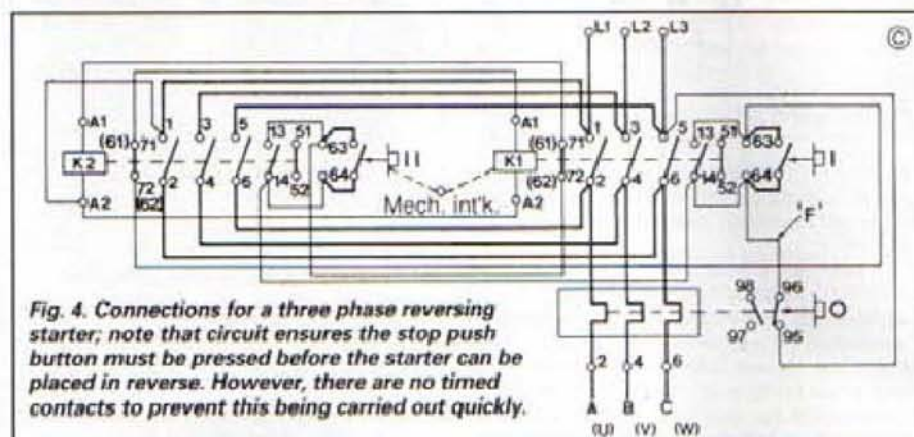


Fig. 4. Connections for a three phase reversing starter; note that circuit ensures the stop push button must be pressed before the starter can be placed in reverse. However, there are no timed contacts to prevent this being carried out quickly.

starting, easily reversible, smooth running and more efficient than their single phase counterparts. They also have ideal torque/speed characteristics for machine tools. The use of a starter with this type of motor is, however, even more essential and the wiring of a simple direct in line starter is shown in **figure 3**. The principle of operation is identical to the single phase starter and the only difference is that the coil is now wired between two phases which means that it is rated at 415 instead of 240 volts. Reversing direct on line starters are also available and a wiring diagram is shown in **figure 4**.

There are now three control buttons marked FORWARD, REVERSE and STOP. The principle of operation is exactly the same as in **figure 3**, but two contactors are used, one each for forward and reverse speeds. If the wiring is followed through, it will be seen that two phases are interchanged in order to reverse the motor. Three phase motors can be considerably more powerful than single phase ones and in many applications it may be desirable to start the motor slowly. The device which achieves this is called a 'soft start' module and it has two main areas of application.

The first is to provide a gentle start where the motor is running machinery with fragile products such as a packing line and the second is a situation where shock loading on starting may damage power transmission components such as gearboxes, belt or chain drives. Obviously machine tools come into the latter category and soft starters will reduce wear and tear. They are connected in series with a conventional starter and make use of the principle of phase control in one of the phases while the other two phases are connected direct to the supply.

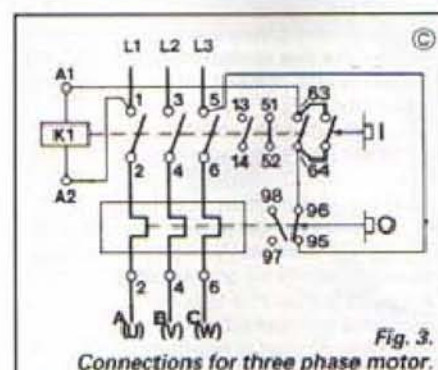


Fig. 3. Connections for three phase motor.

Sources and acknowledgements

Yellow Pages under Electrical Supplies is a good source for anyone looking for a local supplier of starters.

Crabtree Electrical Industries control equipment division, are one of the main manufacturers in this country. Their head office is Lincoln Works, Walsall, WS1 2DN. Tel. 0922 721202 and they may be able to provide the address of a local supplier in case of difficulty. The author wishes to thank them for permission to use illustrations from their catalogue in this article.

Electromail, the postal division of RS Components, stock soft starters. They can be contacted at PO Box 33, Corby, Northants NN17 9EL. Tel. 0536 204555.

Machine Mart who advertise widely and have branches throughout the country, stock a range of single phase motors with starters. Their head office is in Lower Parliament Street, Nottingham. Tel. 0602 411200.

The author has no connection with any of the above firms.

In the recent article on aligning a lathe, by Bill Morris (MEW Feb/Mar '92), he referred to a requirement for a precision level, stating that one with a calibration of 60 seconds per division was barely adequate.

I must confess that this value was largely meaningless to me. Small divisions of, say, 1 thou. or 1 milli litre, or even 1 gram I could visualise, but an angle of 60 seconds I could not. I knew this to be a small angle, but beyond that I was lost.

Bill did go on to explain that the need to detect errors of 10 seconds was about 0.04mm error in 1 metre. This led me to consider what I had available in the workshop, though I realised that nothing was in any way close to this.

My builder's level would give a 2mm movement to the bubble for an 8mm error over 1 metre. The level in my combination set protractor was surprisingly even less accurate, requiring about a 10mm error over 1 metre for a similar movement of the bubble.

Being able to detect 10 seconds, of course, does not mean that it must be calibrated in 10 sec. divisions. With a vial having divisions equalling 60 seconds and with the division lines as is likely about 2mm apart, then to detect 10 seconds should be possible.

As purchasing a level would be costly, those sold by College Engineering as a casting and vial were considered. Their catalogue shows a base available in either aluminium or cast iron, the standard vial supplied has a sensitivity of 0.41 degrees (7mm per metre).

Alternative vials are available having sensitivities of 0.15 degrees (2.6mm per metre) and 0.033 degrees (.57mm per metre). The brass tube is also supplied with the standard vial, but not with the other two. With the most sensitive vial, errors of 0.1mm per metre should be detectable – not quite as accurate as advised by Bill Morris, but close.

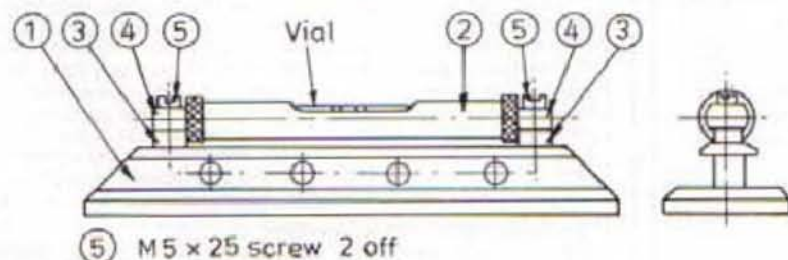
Most people will only be familiar with the common builder's level with the vial in the form of a bent tube, and will be



Photo 1. Finished level complete with storage case.

AN ENGINEER'S LEVEL

This engineer's level will provide an interesting project with some particularly interesting milling operations. It will also be a useful instrument in carrying out the operations detailed in the last issue for aligning a lathe after installation...



ASSEMBLY: ENGINEERS LEVEL

surprised to find that the tube is straight. In precision vials the curve is produced on the inside only; this is done by grinding.

The two precision vials are larger in diameter than the standard vial, this being the reason the tube is not supplied. Therefore the assembly requires slight modifications from that shown on the College Engineering drawings, and can either be made from larger diameter, or thinner walled tube. The same outside diameter but with a thinner wall was the approach chosen.

Whilst drawings are supplied with the

parts, a full set of drawings is included with this article, as they reflect the changes necessary for the precision vial.

One other change made, the purpose of which was to save time, was to make the tube end pieces a push fit by hand, rather than the more professional threaded arrangement proposed by College Engineering. To make this simplification practical, the depth of engagement was increased to 18mm. Those readers who find this approach unacceptable can revert to threaded ends which would have to be 14.5mm diameter.

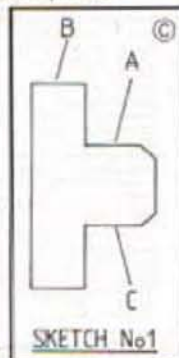
The base

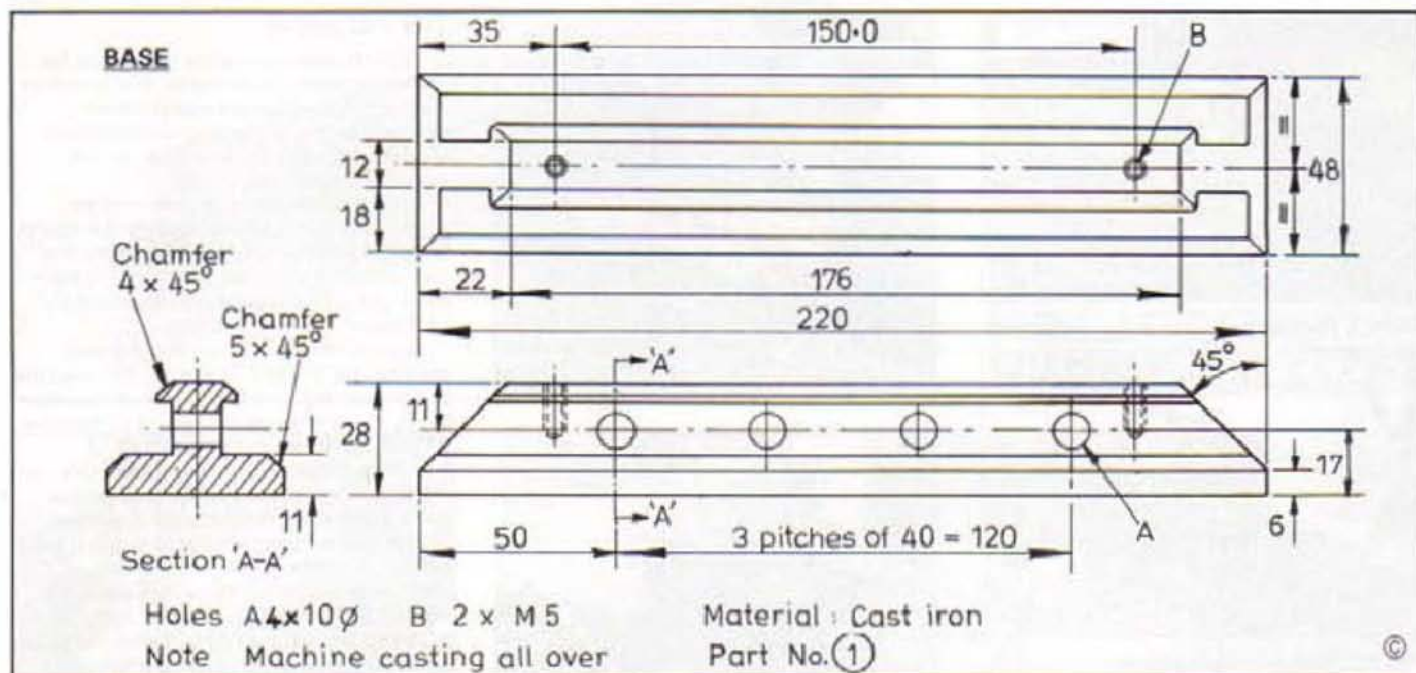
Other than the size and shape of the casting, which may present some problems with holding the part, machining the casting should be quite simple. The sequence suggested here is by no means the only method that can be adopted, but should be found suitable for those with limited work holding facilities. The problem is likely to be the absence of a suitably large vice and angle plate.

Clamp two pieces of rectangular steel to the machine table to form an angle plate. This arrangement is shown in **photograph 1**; set the front one of the two pieces parallel to the movement of the slide.

Clean up the casting with a file removing any projections that may prevent it sitting firmly when clamped in position. Clamp the bottom of the level to the steel pieces as shown in **photograph 2**, and machine faces A and B (indicated in **sketch 1**).

Turn over casting and with face B firmly against





the milling machine table, or suitable packing piece, machine face C. This will ensure faces A and C are parallel along their length.

The casting can now be lightly gripped on faces A and B with two substantial toolmaker's clamps, and the arrangement now clamped to the machine table, as shown in **photograph 3**. Note the packing pieces below the clamps that make sure the clamps, and not the casting, are clamped to the table.

Care must be taken in this operation not to distort the casting, for if the toolmaker's clamps are tightened firmly before clamping to the table, twisting of the casting may occur. To avoid this, progressively tighten all four clamps in turn.

The base of the casting can now be machined; take care to set the cutter for the first cut, below the harder outer skin. The base as cast will not be flat, and what starts as an adequate cut may eventually be too shallow as it passes across the surface. Watch out for a shiny surface to indicate that the cut requires to be set deeper.

Remove the casting and clamps from the table, and return the casting to the table, base down as is shown in **photograph 4**. Machine the top face, only just sufficient to clean the surface, as this will be finished at a later stage.

Recreate the makeshift angle plate as was used for the original machining, and clamp the casting on to this as in **photograph 5**. Make sure the surface B is fully in contact with the table or packing piece.

Now start to machine the slot along the side. Make the depth such that, when machining the second side, approximately equal amounts will be required to be taken from either side. The width of this slot is not critical, and if a 12mm end mill is not available but a 1/2 inch end mill is, use this. This is better than using a smaller end mill and creating the slot in two passes. With the base still in position, machine also the edge of the base as in **photograph 6** to give the 18mm dimension.

Turn the casting over and produce the second slot, such that the thickness of the central web is 12mm. Follow this by

machining the second edge, again to achieve the 18mm dimension.

If a long adjustable angle plate is available, machining the chamfers should present no problem. If not then the arrangement shown in **photograph 7** should suffice, providing only light cuts are taken.

Start by taking only a light cut; check to determine if an equal cut is being taken along the length, this to ensure an equal chamfer results. If not, adjust to achieve this aim as otherwise an acceptable appearance will result.

To machine the angle on the end, fix a small angle plate at 45 degrees onto a larger angle plate. Clamp the base onto the small angle, and machine the angle as shown in **photograph 8**.

Clamp the base onto the machine table

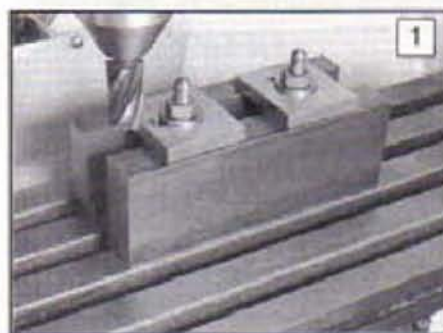


Photo 1. An alternative arrangement for an angle plate



Photo 3. The set-up for machining the base; note how clamps grip central web and are then clamped to machine table.

making sure the base is parallel with table travel, and machine the ends as shown in **photograph 9**. Do pack up the base from the machine table to avoid the cutter fouling the table. Follow this by machining the top surface to the 28mm dimension.

With the base still mounted in the same manner, machine both sides of the top part of the central web, as in **photograph 10**. Take a light cut only to start with, check if the resulting flat will be equal along its length, and if not adjust to suit. Again this is not essential, but appearance will suffer if the resulting flat is not parallel.

Now again recreate the angle plate as in **photograph 1**. Clamp on base and, using a centre drill, mark off the 4 x 10mm holes, positioning these using the machine dials. It is here that one of the weaknesses of the usual mill/drill may become apparent.

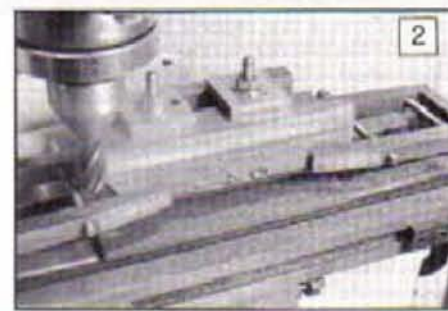


Photo 2. First machining operation; cutting the central web for gripping with toolmaker's clamp as shown in photo 3.



Photo 4. Finishing the top.



Photo 5. Making the groove in the central web.



Photo 7. Making the chamfers.

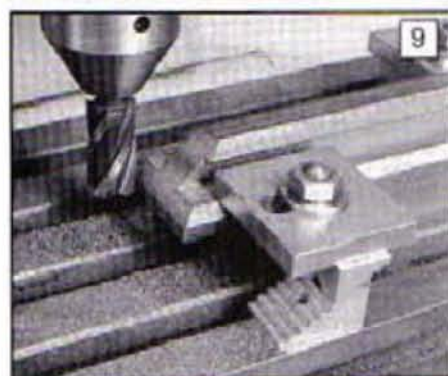


Photo 8. Machining the end of the base.

If the head of the mill/drill has been in a low position to use the centre drill, then probably it will require to be raised, to get the longer 10mm drill into position. The result of this is that register between the drill spindle and the positions already established, will be lost due to the round column.

Line up the drill with the first centre mark and zero dials; drill first hole. Now drill remaining holes, again using the machine dials to position the base correctly; this is seen in **photograph 11**.

All that remains is to drill and tap the M5 holes in the top and to make an appropriate 1mm chamfer on all edges (**photograph 12**).

As removing so much metal from all

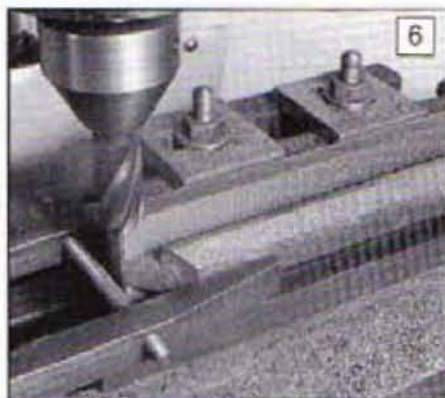


Photo 6. Machining the base to final width.



Photo 8. Finishing the angle on the end.



Photo 10. Machining width of top to final dimensions.

faces of the casting, it is possible that internal stresses may cause the casting to change. This may result in the base, being one of the first surfaces to be machined, becoming distorted.

Before proceeding check the base on a flat surface, any very minor errors could be removed by scraping. More severe errors would require both the bottom and top faces to be remachined, removing only a few thou. This test would best be carried out a few days after completing machining.

The vial carrier

With the base complete the carrier for the vial requires to be made. The precision vial supplied measures about 13mm diameter and is larger than the standard vial for which the College Engineering drawings are prepared.

Brass tube $\frac{1}{8}$ inch diameter with an 18swg wall thickness will enable the design to be followed closely, other than for the diameter of the thread. Whilst not in their catalogue this size tube was supplied by GLR Distributors.

Having limited time available it was decided not to use a thread for securing the end pieces, but to rely on a parallel portion being a very close fit in the end of the tube. To give this method more chance of working satisfactorily, the depth of this insert was increased from 12mm for the threaded end to 18mm for the plain end.

This proved very satisfactory and the drawings published with this article indicate this method. Drawings showing threaded ends will be provided with the base and can be worked to if preferred. The thread will though have to be a larger diameter, due to the larger bore of the tube.

Saw off a length of brass tube and carefully face both ends to the required length. Remove any burrs from inside the bore as these may cause confusion when turning the ends to a close fit.

Place vice on milling machine table and ensure it is positioned accurately – that is at right angles to length of table. Make slot as seen in **photograph 13**.

The outside of the tube may be left as supplied, or alternatively can be turned to give it a machined surface. To do this, place a short length of $\frac{1}{8}$ inch dia. steel in the three jaw chuck. Turn a tapered stub mandrel to support one end of the tube (**photograph 14**) whilst the other end is supported by the tailstock centre (**photograph 15**).

Two points require to be taken note of to avoid the possibility of failure. First, the end supported by the centre will have a sharp edge that will quickly wear. This will

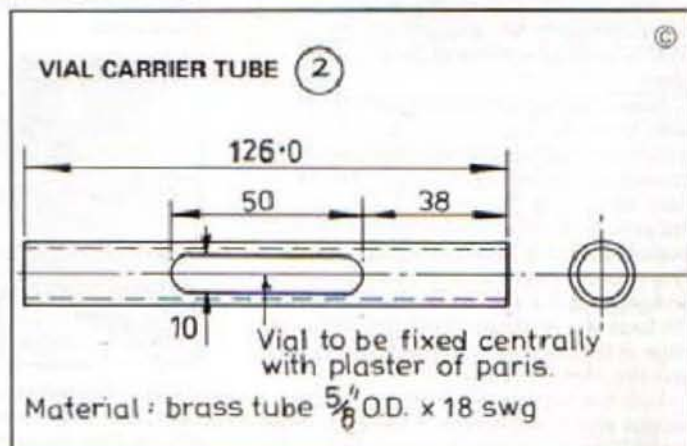
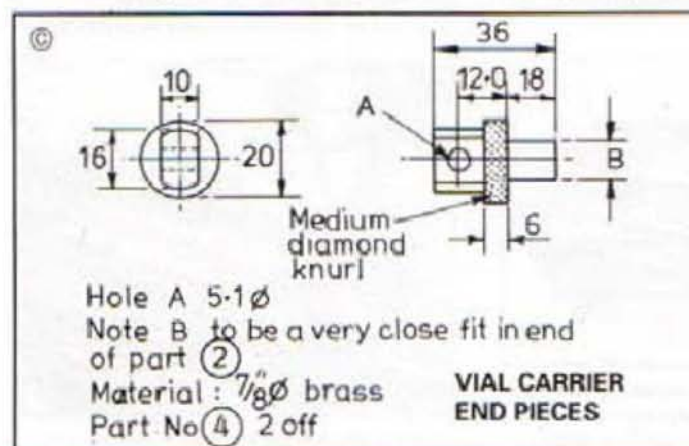
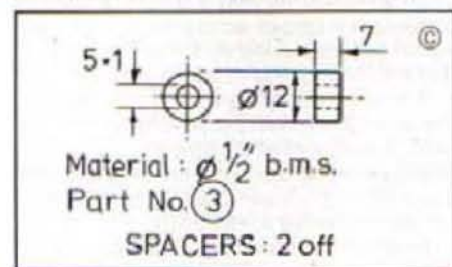




Photo 12. The finished base; note the all edges have been given a $\frac{1}{16}$ " chamfer with a fine file.

QUICK TIP

New or perfect high speed steel taps make quite acceptable reamers for short holes. The square end has nice sharp cutting edges when new almost as good as a D bit, so as there is a large range of shank sizes used for taps you have more reamers than you think you have. I discovered this when making adaptor collars for a tailstock tap holder, what better than the taps themselves.

G. K. Bartlett



Photo 11. Drilling holes in central web after first positioning them with centre drill.

result in the part becoming loose when machining commences, and a poor finish resulting. To avoid this run the lathe for a short while without taking a cut, but progressively advancing the tailstock barrel by a very little. Do this until the edge has become slightly worn; use oil during this operation.

The second possible cause of a problem will be if the part is forced further onto the stub mandrel during machining, resulting in the part becoming loose at the tailstock end. To overcome this possibility, turn the mandrel with a greater internal angle than would normally be used. Setting the top slide to an angle of 2 to 3 degrees, rather than the normal 1 to 2 degrees, should prove satisfactory providing the part is pressed well home before machining.

Having made these preparations, machining the outside of the tube should present no problems.

Follow this by making the two end pieces. **Photograph 18** shows this being done using a fixed steady to support a long bar, and machining the part on the end. This is by no means essential, but it will avoid ending with small pieces which remain when parting off a part from material, just held in the chuck. Using this method is always a worthwhile consideration, particularly for the more expensive materials.

First machine the end that goes into the tube. This requires to be a very firm push fit by hand. To achieve this, the diameter will be required to be finished to a very precise size; a 0.005mm difference will result in it either being too tight to insert or, on the other hand, too loose. Because of this, very precise control of the diameter will be necessary.

The best method for arriving at this precise control of diameter is to set the top slide to an angle of about $\frac{1}{2}$ degree. Then winding the slide back will result in a depth of cut of 0.001mm for a 0.1mm movement. Use the saddle to turn the



Photo 13. Slotting the vial tube (above).

their end of the tube.

The parts can now be held in the three jaw chuck on the parallel portion just turned, and the outer diameter created. Any marks created on the turned surface by the chuck jaws will be of no concern, as they will be hidden when fitted into the tube.

Accuracy

It is at this point that it is worth considering the differing demands for accuracy which the three vial sensitivities require. The figures quoted here are only approximate, and serve to illustrate the requirements only.

If the base was machined in the manner described above on a reasonably accurate machine, then the lower and upper faces should be parallel to a very close tolerance. As a result, only the vial mounting arrangements require considering.

Three items will effect the accuracy of the final assembly. These are the mounting of the vial in the tube, any differences between the two end pieces and, similarly, any difference between the two pacers.

The three sensitivities amount to errors of 1.4mm, 0.5mm and 0.1mm over



Photo 14. The vial tube mounted on a tapered stub mandrel.

part parallel (see *Quick Tip*, page 16 Dec.91/Jan.92 issue).

It is possible that the inside diameter of the tube may vary slightly from one end to the other; scribe a line inside the tube and always test using this end. When a satisfactory fit is arrived at, scribe a line on the turned portion only.

Now produce the knurling and part off first part to length. Follow this by producing the second end piece, making sure it is made to fit the other end of the tube. Do not mark this end to ensure that the end pieces will always be fitted to

200mm, this relating to the bubble moving one calibration mark, about 2mm. It is obvious from this that quite large manufacturing errors could be inherent in the least sensitive, and for these not to be apparent in the vial reading. Even the middle sensitivity should work adequately first time with a little care in making the critical parts.

For the most sensitive vial, the situation is quite different. Here it is unlikely that the unit will work satisfactorily, no matter how much care is devoted to manufacturing the parts. This will result in the requirement for some adjustment to be made on final assembly.

Returning now to the two end pieces on



Photo 15. Machining the vial tube; note how this is supported between stub mandrel and tailstock centre.

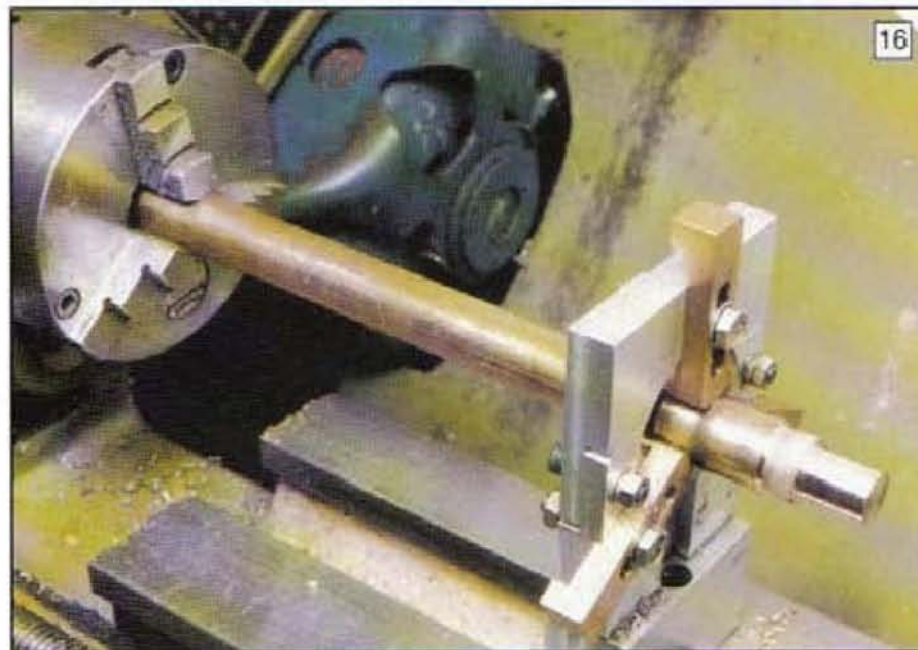


Photo 16. Making the vial tube ends; the fixed steady is being used to minimise scrap.

which the flats require to be made. The method of doing this is shown in **photograph 17**: do attempt to get the tabs that result, central, by machining the equal amounts from both sides. In any case it is worth marking two sides machined at the same pass, and then ensuring they are used the same way up when fitted.

Spacers

These present more of a problem than is apparent at first consideration. This is particularly so for the most precise assembly. Make two spacers both the same length. To do this, machine a short length of $\frac{1}{2}$ inch diameter to the required size, and drill through sufficient to make two spacers.

Now set the rear parting off tool at a position to make a spacer a few thou. longer than required. Do not move the saddle but bring into position a facing tool on the top slide, face off a few thou. using only the top and cross slides, and then part off.

For the second spacer, do not move the top slide but bring the facing tool into position using the saddle and face off a few thou. to clean up this surface. Again, part off using the cross slide only, both spacers should be the same length and have parallel faces.

The full set of parts is now complete and these can be seen in **photograph 18**.

Assembly

The first stage of the assembly procedure will be to paint the rear of the vial with white paint, and allow it to dry. With this done, fix the vial in position using plaster of Paris or similar. Position such that any excess clearance is below the vial, so that it is positioned close against the opening in the top of the tube.

When set, the final assembly can take place. If the fit between tube and ends has been made quite tight, cooling the ends in the freezer will help to ease the assembly. The finished level is seen in **photograph 19**.

Calibration

Calibrating the finished unit will depend on which level of accuracy has been made. The two lower levels should present no real problem, and the procedure for the precision level only will be discussed, though much of what is said will be appropriate to all three. **Photograph 20** shows the calibrating marks on the vial.

The first problem will be the absence of a sufficiently accurate level surface on which the tests can take place. Because of this it will be necessary to establish the level surface using the level already made, but itself not accurate at this stage.

A surface plate will be a good item on which to carry out the tests; this can be packed up at the corners until level.

Alternatively, a piece of steel, say $1\frac{1}{2}$ in. square and 10 inches long, can be mounted in the vice; this can then be adjusted until a satisfactory level surface is achieved.

First get the surface as level as possible using the most accurate level available. Now place the precision level on the surface and note the reading; turn the level through 180 degrees and again take note of the reading.

Almost certainly errors will be present in both the surface and the level itself which will make analysing the readings difficult. First let us consider the unlikely event of the surface already being perfectly level. In this case, if the bubble reads to the left in the first position, it will read the same amount to the right when reversed. If the reverse were the case, that is the level being correct, then if the bubble first reads to the left it will still read to the left by the same amount when moved through 180 degrees.

Almost certainly an error will exist in both cases. The result of this will be that the bubble is biased say to the right in the first test, and will be biased to the left in the second test but by a different amount.

Adjust the surface on which the test is being carried out until the error indicated is equal in both directions. At this point the surface can be considered level. When subsequently the level itself is adjusted to be nearer correct, it will be worth returning to the test surface to make further minute adjustments.

With the surface now reasonably accurate, it is time to adjust the spirit level. To do this place the level on the test surface and, using feeler gauges under the base at one end, determine how much it

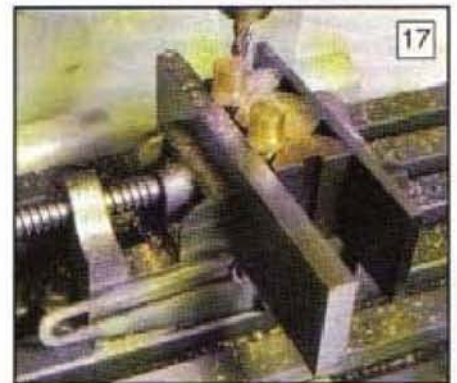


Photo 17. Making the ears on the vial tube ends.

has to be raised to make it read level.

To correct for the error remove the spacer from the other end and reduce the thickness of this to suit. This will be about $\frac{1}{4}$ of the error measured over the total length.

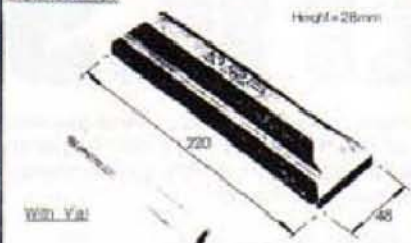
The method of doing this is to turn a stub mandrel to be very close fit in the hole, with the spacer placed on this the length can be reduced to suit. This is more difficult than may be anticipated as, when the level approaches its required calibration, corrections of only a 0.002mm will be required.

In setting up the prototype it was sometimes found that, when returning the spacer after machining, the opposite effect to that anticipated resulted. This situation was difficult to understand but was eventually put down to the fact that the two sides of the spacer sometimes were not

Suppliers

The Collage Engineering Supply,
2 Sandy Lane, Codsall, Wolverhampton
WV8 1EJ, 09074 2284

ALCA CAST 800
CHILL ALUMINUM



Standard Vial - Sensitivity
For No 12-541 Bubble Movement - Angle = 0.41° Ref. 541D
Also available in place of Standard Vial and Brass Tube
For No 12-541 Bubble Movement - Angle = 0.15° Ref. 541E
For No 12-541 Bubble Movement - Angle = 0.033° Ref. 541F

ENGINEERS' SPIRIT LEVEL

No 541

GLR Distributors Ltd. Great
Northern Works, Hartham Lane, Hertford
Hertfordshire SG14 1QN, 0992 552962

Level Developments Ltd., 7-9
Hildrith Mews, London SW12 9RZ, 081-
873 6823

parallel by up to 0.005mm.

Under these circumstances, the way round the spacer was fitted could have a marked effect, as this would either attempt to tilt the tube end pieces, either up or down.

When finally adjusted, place on the surface and pack one end just sufficient to move the bubble one division; this should be around 0.1mm. This will serve as an indication to you how accurate



Photo 18. The complete set of parts.

end, but in the other, screw a stud firmly into the tapped hole. If nuts are now used on either side of the ear on the vial tube end piece, adjustment will be much easier, though the result will look a little untidy.

Storage box

This is a precision and delicate piece of equipment that will not find frequent use, but will be invaluable when the need arises. In view of this a storage box is worth making to protect the unit when not being used.

Details for making this are not included; it can be a jointed assembly as one would expect when purchasing precision equipment, or alternatively butt jointed as shown in the photograph.

Use lamin (obtainable from DIY superstores) for the sides and ends, and thin three ply for the top and bottom. Rapid

QUICK TIP

It is sometimes difficult to set up a gear train with the correct amount of back-lash.

A quick way of solving this problem is to trap a piece of paper between the gears when they are meshed. The paper will fall out when the gears are rotated, leaving a clearance.

As there are many thicknesses of paper, it should be easy to find a thickness to suit any gear train, from a cigarette paper for high precision small gearing, to writing paper for the less precise and even thicker if one of the gears isn't running as true as it should.

R.J. Loader

setting two-part adhesive will give a good result and enable the case to be finished quickly. Finish with a coat of varnish and some green baize or similar inside will complete the project.

The level complete with its storage case is seen in **photograph 21** at the start of this article.

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Photo 19. The finished level.

the level is, also that you have been supplied with the correct vial, as there is no way of knowing by just looking at it before assembly.

This method of adjusting the level was more difficult than anticipated. An alternative would be to use a spacer at one



Photo 20. The vial calibration; each line is about 2mm apart.

Greater precision

Any reader who considers that it would be preferable to make a level to higher degree of precision, may like to obtain a more sensitive vial. This is likely to be prohibitively expensive for a supplier to make a one off, probably about £40.

It is possible though that a supplier may have a suitable vial in stock, having been made in excess of requirements of an earlier batch. One such supplier of vials and complete assemblies is Level Developments Ltd.

WORKSHOP MATHEMATICS

For many operations, the ability to carry out some mathematical calculations will either be essential or, at least, considerably beneficial to the task in hand. It is hoped that this short article will be of benefit to those who find this aspect of workshop activities somewhat confusing

The operation of workshop machinery for the manufacture of original components cannot be accomplished fully without the need to carry out some basic mathematical calculations. Equally, or perhaps more so, this is the case for much marking out.

For many, particularly those coming to the hobby at a later age, the requirements will be a distant memory of time at school. To assist those who wish to brush up on their mathematics, this brief refresher course will hopefully be of help!

It is assumed that the very basic requirement of multiplication, division and similar will be already understood. Also that a basic calculator will be available, and as a result, logarithms will not be covered.

The problem for many will be the inability to translate the practical problem before them into the theoretical mathematic formula required to solve the problem.

In this brief article it is intended to cover only those formulae relating to the circle and the triangle. All such calculations will be dependent on knowing the formula, and having available the value of any constants required to complete the calculations.

The circle

Probably by far the most used and well known example of this is the calculation for the circumference of a circle. This uses the constant with the value of 3.1416 known as pi (π).

In this case, the circumference of a circle is $3.1416 \times \text{diameter}$ and is valid no matter what the size of circle is. This expressed in the form of a mathematical formula is:

$$\text{Circumference} = 3.1416 \times \text{diameter}$$

Other similar formula relating to circular forms are:

$$\text{Area of circle} = 3.1416 \times \text{radius} \times \text{radius}$$

$$\text{Volume of a cylinder} = 3.1416 \times \text{radius} \times \text{radius} \times \text{length}$$

The last one is useful to calculate the volume, and thereby the weight, of a piece of metal being purchased.

The triangle

The quantity of constants required to complete calculations relating to triangles is very large. They can only be arrived at by the use of trigonometrical tables.

The normal trigonometrical constants only relate to triangles of which one corner is a right angle (90 degrees). For more complex triangles the calculation would normally be accomplished by breaking the triangle into two right angle triangles.

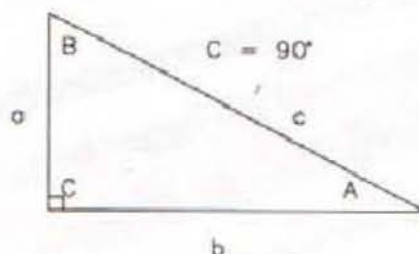
Here, like the circle, the constant will be appropriate for any size of triangle, though of course there will be a different constant for each shape. Hence the reason for these to be found by reference to a published table.

A simple example of this is that, for a 30 degree triangle, the long side will always be twice the length of the shortest side, irrespective of size. Similarly, for other angles the ratio will be a constant, but of course in most cases will be more complex than a whole number.

To assist with this article a brief table is published showing those values for whole degrees. For values in degrees and minutes, full trigonometrical tables should be referred to.

There are six parameters relating to a triangle, being three sides, and three angles. In addition to knowing that one angle is a right angle, at least two other parameters must be known to complete the calculations relating to a given triangle.

At least one of these parameters must be a length, though it is sufficient to have a second length, and no angle. First we must set out our basic triangle being as follows:



This indicates that a, b and c are the sides, and A, B and C are the angles. Note the convention that angle A is opposite side a, and similarly for the other sides and angles.

Other than those using the trigonometrical factors, there are two other formulae relating to the triangle, which are very useful.

The first states that the sum of the three angles will always be 180 degrees; this is the only formula which also applies to triangles without a 90 degree corner.

$$A + B + C = 180 \text{ degrees}$$

The second is the well known Pythagoras Theorem which states that the sum of the square of the two shorter sides, is equal to the square of the long side.

$$(a \times a) + (b \times b) = (c \times c)$$

The well known example of this is the

simple one which works out with the whole numbers of 3, 4 and 5, this ratio frequently being used to lay out right angle corners in the building trade, etc.

$$(3 \times 3) + (4 \times 4) = (5 \times 5) \\ 9 + 16 = 25$$

This will, of course, work out with all right angle triangles, but the result will be more complex numbers.

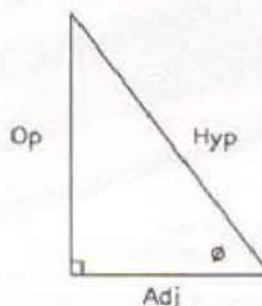
The remaining three formulae which use the constants taken from the tables are variations on the same principle. The one used in any calculation will depend on the combination of parameters known. That is to say, if side a and angle B were known, one formula would be used, whilst if it were say side C and angle B, it would be another.

Each of the three formula uses a constant taken from a different trigonometrical table; these are known as Sine, Cosine and Tangent, abbreviated as Sin, Cos and Tan.

The tables are in the form of a value for a given angle. Sometimes the angle will be known and the value will be the item being looked up; in other cases the value will have been calculated and it will be the angle being sought.

The three formulae are best stated, with the triangle considered in a different manner to that shown above.

The formula are expressed using the following:



θ (theta) – this is the angle known or being calculated.

Op (opposite) – this is the side opposite the angle θ .

Hyp (hypotenuse) – this is the longest side (opposite the 90 degree angle).

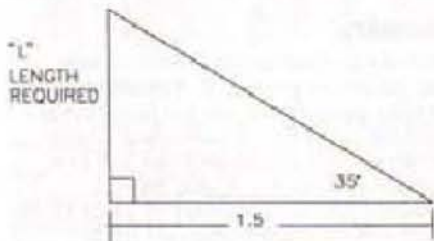
Adj (adjacent) – this is the side adjacent to the angle θ which, together with the hyp, makes the angle θ .

The three formulae are:

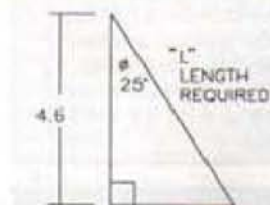
$$\begin{aligned} \text{Sin } \theta &= \frac{\text{Op}}{\text{Hyp}} \\ \text{Cos } \theta &= \frac{\text{Adj}}{\text{Hyp}} \\ \text{Tan } \theta &= \frac{\text{Op}}{\text{Adj}} \end{aligned}$$

Turning a taper

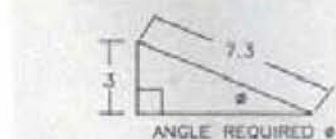
At this point, some simple examples are given



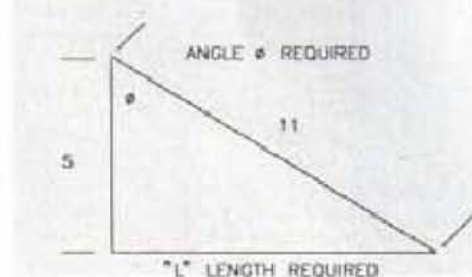
KNOWN $\phi = 35$
 ADJ = 1.5
 OP
 USE $\tan \phi = \frac{OP}{ADJ}$
 $\tan 35 \times 1.5 = L$
 LOOK UP $\tan 35$ FROM TABLES
 THIS EQUALS 0.7002
 $0.7002 \times 1.5 = L$
 LENGTH REQUIRED = 1.0503



KNOWN $\phi = 25$
 ADJ = 4.6
 USE $\cos \phi = \frac{ADJ}{HYP}$
 $\cos 25 \times HYP = ADJ$
 $HYP = \frac{ADJ}{\cos \phi}$
 $HYP = \frac{4.6}{0.9063}$
 LENGTH = 5.0756



KNOWN OP = 3
 HYP = 7.3
 USE $\sin \phi = \frac{OP}{HYP}$
 $\sin \phi = \frac{3}{7.3}$
 $\sin \phi = 0.4109$
 FROM $\sin$ TABLES $0.4109 = 24^\circ 15'$



FIRST USE PYTH THEOREM
 $(5 \times 5) + (L \times L) = (11 \times 11)$
 $(L \times L) = (11 \times 11) - (5 \times 5)$
 $(L \times L) = 121 - 25$
 $(L \times L) = 96$
 $L = \sqrt{96}$
 $L = 9.798$

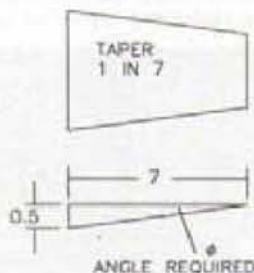
NOW KNOWING THE LENGTH OF ALL THREE SIDES, ANYONE OF THE THREE FORMULE CAN BE USED, TO CALCULATE ϕ , USE THE FORMULE THAT REQUIRES THE TWO SIDES INITIALLY KNOWN.

USE $\cos \phi = \frac{ADJ}{HYP}$
 $\cos \phi = \frac{5}{11}$
 $\cos \phi = 0.4545$

FROM THE $\cos$ TABLES
 $0.4545 = 62^\circ 57'$

These are basic mathematical examples; a practical example will now be illustrated. Consider a taper of 1 in 7 to be turned using the top slide and which initially, at least, can be set using the top slide calibrations.

The top slide must be set to the half taper being 0.5 in 7, and it is this angle which requires to be calculated, as follows.



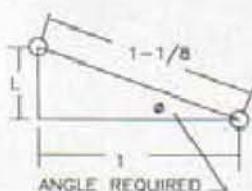
KNOWN OP = 0.5
 ADJ = 7.0
 OP
 USE $\tan \phi = \frac{OP}{ADJ}$
 $\tan \phi = \frac{0.5}{7.0}$
 $\tan \phi = 0.0714$
 FROM $\tan$ TABLES $0.0714 = 4^\circ 5'$

Lever for toggle clamp

For a further example, consider the article elsewhere in this issue, regarding the vertical toggle clamp. The operator for this shows two holes at a radius of 1 1/8 inches.

Anyone making this part may prefer to mark this out using a height gauge as a more accurate way of doing this.

Some may choose to set the part up on a right angle plate, but clamped on at the appropriate angle and, again using a vernier height gauge, mark out the 1 1/8 inch dimension. Not really a practical suggestion but it serves to provide an example:



TO CALCULATE L USE PYTH THEOREM
 $(L \times L) + (1 \times 1) = (1.125 \times 1.125)$
 $(L \times L) = (1.125 \times 1.125) - (1 \times 1)$
 $(L \times L) = 1.2656 - 1$
 $(L \times L) = 0.2656$
 $L = \sqrt{0.2656}$
 $L = 0.5154$

TO FIND ϕ USE $\cos \phi = \frac{ADJ}{HYP}$
 $\cos \phi = \frac{1}{1.125}$
 $\cos \phi = 0.8888$

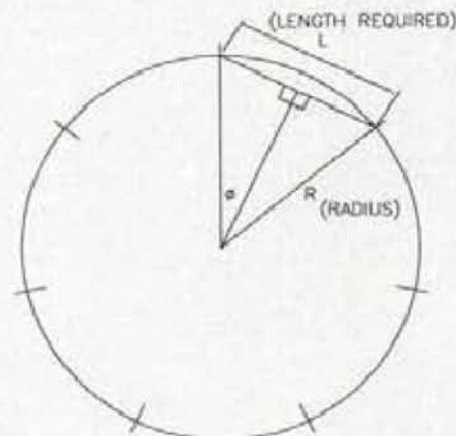
FROM $\cos$ TABLES $0.8888 = 27^\circ 16'$

Divisions on a pitch circle diameter

When drilling holes on a PCD in the absence of some dividing method, say to make a simple dividing plate, the hole positions can be calculated.

The acceptability of this method will depend on the degree of accuracy required, and this will also be dependent on the number of divisions required. The greater the number of positions the greater the error probable.

It is not intended to go into the method in detail, only the mathematics to make the idea possible. Briefly though this approach assumes it is to be marked out using dividers, and the accuracy will depend on how accurate these are set and applied to the task. If a dividing plate is being made then the angular error, being the important consideration, can be reduced by making the PCD as large as is practical.



TO CALCULATE LENGTH OF ARC L
 N = NUMBER OF DIVISIONS.
 $\phi = \frac{360}{2 \times N}$

USING $\sin \phi = \frac{OP}{HYP}$

OP = $\frac{L}{2}$ AND HYP = R

THEREFORE $\sin \phi = \frac{L/2}{R} = \frac{L}{2R}$

AS $2R = PCD$
 $\sin \phi \times PCD = L$

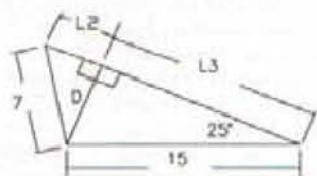
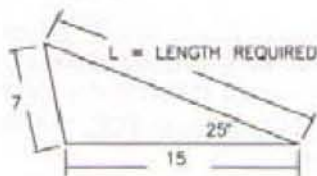
LENGTH OF ARC $L = \sin \phi \times PCD$

NOTE ANGLE ϕ IS HALF OF ANGLE REQUIRED.

There are also methods for calculating unknowns with regard to non-right angle triangles, but this is going beyond the intentions of this article.

Where this requirement occurs, it is better to endeavour to complete the calculation, using the formula so far described.

The method is to break the triangle into two or more right angle triangles, for which sufficient is known to enable calculations to be made. These collectively will be able to arrive at the required result. This is best understood by following the example below.



THE ABSENCE OF A RIGHT ANGLE CORNER, MAKES IT IMPOSSIBLE TO CALCULATE LENGTH OF SIDE L, DIRECTLY FROM THE FORMULAE GIVEN.

CONSTRUCT LINE D, TO CREATE TWO RIGHT ANGLE TRIANGLES.

NOW CALCULATE LENGTH D

$$\begin{aligned} \text{USING } \sin \theta &= \frac{\text{OP}}{\text{HYP}} \\ \sin 25 &= \frac{D}{15} \\ (\sin 25) \times 15 &= D \\ 0.4226 \times 15 &= D \\ 6.339 &= D \end{aligned}$$

NOW CALCULATE L3, USING PYTHAGORAS' THEOREM.
 $(DXD) + (L3XL3) = 15X15$
 $(15X15) - (DXD) = (L3XL3)$
 $(15X15) - (6.339X6.339) = (L3XL3)$
 $225 - 40.183 = (L3XL3)$
 $184.817 = (L3XL3)$

$$\sqrt{184.817} = L3$$

$$13.595 = L3$$

NOW CALCULATE L2, IN A SIMILAR MANNER, TO GET

$$2.969 = L2$$

$$\text{LENGTH REQ. } L = L2 + L3$$

$$L = 13.595 + 2.969$$

$$L = 16.564$$

Readers who wish to take this exercise further may like to consider purchasing the *Model Engineers' Handbook* by Tubal Cain

and published by Argus Books. This book has additional details of workshop calculations, full 4 figure trigonometrical tables, and a mine of information on other topics.

Geometry

Not really mathematics but a closely allied subject is geometry. A small number of simple geometric rules are beneficially employed in the home workshop. These geometric rules will be covered in a brief follow-up articles in the next issue.

Model Engineers' Handbook, price £6.95, p&p 70 pence, can be obtained from: Combined Book Services, 406 Vale Road, Tonbridge, Kent TN9 1XR. Cheques payable to Combined Book Services. Credit card orders 0732 357755.

Post script

Should any reader still find the contents of the article too demanding, and would like to start at the earlier level of algebra (that is the representation of quantities by symbols and their manipulation within formulae), will they please let me know.

As a result of the number of replies received, I will either publish another article, or make available on request some photocopied notes which I will indicate as available in a future 'On The Editor's Bench' (Ed.)

COSINES				TANGENTS				SINES			
Degrees	0'			Degrees	0'			Degrees	0'		
0	1.000	44	.7193	0	0.000	44	.9657	0	0.000	44	.6947
1	.9998	45	.7071	1	.0175	45	1.0000	1	.0175	45	.7071
2	.9994	46	.6947	2	.0349	46	1.0355	2	.0349	46	.7193
3	.9986	47	.6820	3	.0524	47	1.0724	3	.0523	47	.7314
4	.9976	48	.6691	4	.0699	48	1.1106	4	.0698	48	.7431
5	.9962	49	.6561	5	.0875	49	1.1504	5	.0872	49	.7547
6	.9945	50	.6428	6	.1051	50	1.1918	6	.1045	50	.7660
7	.9925	51	.6293	7	.1228	51	1.2349	7	.1219	51	.7771
8	.9903	52	.6157	8	.1405	52	1.2799	8	.1392	52	.7880
9	.9877	53	.6018	9	.1584	53	1.3270	9	.1564	53	.7986
10	.9848	54	.5878	10	.1763	54	1.3764	10	.1736	54	.8090
11	.9816	55	.5736	11	.1944	55	1.4281	11	.1908	55	.8192
12	.9781	56	.5592	12	.2126	56	1.4826	12	.2079	56	.8290
13	.9744	57	.5446	13	.2309	57	1.5399	13	.2250	57	.8387
14	.9703	58	.5299	14	.2493	58	1.6003	14	.2419	58	.8480
15	.9659	59	.5150	15	.2679	59	1.6643	15	.2588	59	.8572
16	.9613	60	.5000	16	.2867	60	1.7321	16	.2756	60	.8660
17	.9563	61	.4848	17	.3057	61	1.8040	17	.2924	61	.8746
18	.9511	62	.4695	18	.3249	62	1.8807	18	.3090	62	.8829
19	.9455	63	.4540	19	.3443	63	1.9626	19	.3256	63	.8910
20	.9397	64	.4384	20	.3640	64	2.0503	20	.3420	64	.8988
21	.9336	65	.4226	21	.3839	65	2.1445	21	.3584	65	.9063
22	.9272	66	.4067	22	.4040	66	2.2460	22	.3746	66	.9135
23	.9205	67	.3907	23	.4245	67	2.3559	23	.3907	67	.9205
24	.9135	68	.3746	24	.4452	68	2.4751	24	.4067	68	.9272
25	.9063	69	.3584	25	.4663	69	2.6051	25	.4226	69	.9336
26	.8988	70	.3420	26	.4877	70	2.7475	26	.4384	70	.9397
27	.8910	71	.3256	27	.5095	71	2.9042	27	.4540	71	.9455
28	.8829	72	.3090	28	.5317	72	3.0777	28	.4695	72	.9511
29	.8746	73	.2924	29	.5543	73	3.2709	29	.4848	73	.9563
30	.8660	74	.2756	30	.5774	74	3.4874	30	.5000	74	.9613
31	.8572	75	.2588	31	.6009	75	3.7321	31	.5150	75	.9659
32	.8480	76	.2419	32	.6249	76	4.0108	32	.5299	76	.9703
33	.8387	77	.2270	33	.6494	77	4.3315	33	.5446	77	.9744
34	.8290	78	.2079	34	.6745	78	4.7046	34	.5592	78	.9781
35	.8192	79	.1908	35	.7002	79	5.1446	35	.5736	79	.9816
36	.8090	80	.1736	36	.7265	80	5.6713	36	.5878	80	.9848
37	.7986	81	.1564	37	.7536	81	6.3138	37	.6018	81	.9877
38	.7880	82	.1392	38	.7813	82	7.1154	38	.6157	82	.9903
39	.7771	83	.1219	39	.8098	83	8.1443	39	.6293	83	.9925
40	.7660	84	.1045	40	.8391	84	9.5144	40	.6428	84	.9945
41	.7547	85	.0872	41	.8693	85	11.43	41	.6561	85	.9962
42	.7431	86	.0698	42	.9004	86	14.30	42	.6691	86	.9976
43	.7314	87	.0523	43	.9325	87	19.08	43	.6820	87	.9986
		88	.0349			88	28.64			88	.9994
		89	.0175			89	57.29			89	.9999
		90	.0000			90	-			90	1.000

TRADE COUNTER

Plastic shims

The requirement to pack up a tool being mounted on the lathe top slide, or in the four way tool post, can be a rather time consuming operation, especially if approached in a haphazard manner. It is so easy to just search around the workshop trying to find some suitable scrap of metal. Some forethought in providing a supply of suitable shims will considerably ease the situation.

Even with this intention, finding a suitable range of scraps from which to make these may not be easy. This can be solved by purchasing a number of small sheets of shim material in a range of thicknesses, from which to make suitable packing pieces.

This can now be done easily by purchasing ready made sets of shim material from Electromail. One particularly useful set is made from plastic and each size is colour coded. The plastic set comprises 8 sheets 12 in. x 6 in. one of each size as follows.

0.002 in. +/- 10% Blue
0.003 in. +/- 10% Green
0.004 in. +/- 10% Amber
0.005 in. +/- 5% Slate
0.0075 in. +/- 5% Natural
0.010 in. +/- 5% Black
0.015 in. +/- 10% Red
0.020 in. +/- 10% Yellow



The plastic shim material as received.

As can be seen, this is not precision shim material. In the package obtained, all sizes were within +/- 0.0002 in. except the Red shim which was 0.0015 in. up.

The two largest sizes are polypropylene, the others polyester. Both materials are resistant to normal oils, etc. The material can be easily cut using a straight edge and general purpose knife. When cut into strips, scissors will be better for cutting to length. Having made a range of packing pieces there will still be plenty left for other purposes at a later date.

The part number is 681-407 and the price £9.00 plus VAT and p&p.

When the tool being packed requires packing by more than say 0.030 in., then most of this thickness should be made up using metal strips. The purist may prefer to use only metal shims, and sets of steel shim material and also brass are available. If this approach is taken then the benefit of colour coding will be lost.

The set of metal shims comprise 8 sheets each 4 in. x 12 in. and with

New items of interest for the home machinist; shims, catalogues and supplies

thicknesses of 0.002 in., 0.003 in., 0.004 in., 0.005 in., 0.006 in., 0.008 in., 0.010 in. and 0.015 in.

The five smallest sizes have a tolerance of +/- 0.0006 in. and the remainder +/- 0.001 in.

The part numbers are:
Steel 680-145 price £10.00 plus VAT and p&p.

Brass 681-249 price £15.60 plus VAT and p&p.

These materials can be purchased from Electromail, PO Box 33, Corby, Northants. NN17 9EL.

Post and packing is a fixed £2.85 plus vat for any size of order. Overseas readers see editorial in the Feb/Mar 92 issue.

Catalogues

A copy of their latest catalogue has been received from **Medina Art Castings Ltd.** This contains a wide range of tools and materials for producing lost wax castings - of course much of what is included also has applications elsewhere.

It carries the full range of requirements from such large items as furnaces and kilns to small tools like stainless steel tongs, plus all the materials required. The catalogue contains 100 pages much of which is devoted to detailed explanations of the various procedures. Send an A4 stamped addressed envelope for a detailed price list, or for the complete catalogue £4.00 to: Medina Art Castings Ltd., The Marine Villa, Undercliff Drive, Ventnor, Isle of Wight PO38 1UW. Tel. 0983 855822.

We've also just received a copy of the latest catalogue from **Essel Engineering**. This contains a good range of materials, fixings and small tools. It also includes Hobbyrat lathes, milling head and milling machine, together with the full range of accessories for these machines. Of particular interest to owners of these machines are a number of special attachments of Essel Engineering's own design.

For model engineering enthusiasts there are a range of loco parts.

The catalogue can be obtained, price 80p from: Essel Engineering, 23 Cavell Road, Billericay, Essex CM11 2HR. Tel. 0277 659774.

Lastly, we've also been looking through the latest catalogue from **J.M.W. (Clocks)**. Whilst this company is primarily established to supply to those interested in clock making and restoring, the catalogue has many items of interest to the home machinist.

The range of items on offer is far too great to attempt to detail, but in addition to parts for clocks and many hand and machine tools, there are also kits of castings and materials for making items of workshop equipment.

One kit that looks very interesting, is for an overhead drive for such equipment as a milling spindle mounted on a lathe. It is shown mounted on the bed of a Series



Plastic Shims cut for use in the four way toolpost, or direct onto the top slide tool

Seven, but is obviously suitable for other lathes both smaller and larger.

The catalogue will prove interesting to any home machinist, and at £3.95 is well worth adding to the library. It can be obtained from: J.M.W. (Clocks), 12 Norton Green Close, Sheffield S8 8BP.

Sources of supply

We would like to thank numerous readers who have provided the following information, too many to detail in the space available. These are in reply to our request for materials and tool suppliers in the last *Scribe a Line*.

1. Left Hand Taps: Tracy Tools Ltd., 2 Mayors Avenue, Dartmouth, South Devon TQ6 9NC. Tel. 0803 833134.

Tilgear, Bridge House, 69 Station Road, Cuffley, Herts. EN6 4TG. Tel. 0707 873434.

2. Stainless steel angle: No reply, though depending on size and requirement for square corners, etc., a local sheet metal worker may be prepared to bend some from sheet.

3. Square silver steel: See number 8.

4. White metal for bearings: Suggestion, try Frys Metals, Mitcham, Surrey.

5. Foundry supplies: Medina Art Castings Ltd. See this page 'Catalogues'. F.L. Hunt & Co., 48 Chapel Street, Manchester M3 7AA.

6. Solidox solid oxygen pellets: No reply. Is there still anyone who could help with this one?

7. Small grinding wheels: Southern Watch and Clock Supplies, 48 High Street, Orpington, Kent BR6 0JH. Tel. 0689 75206.

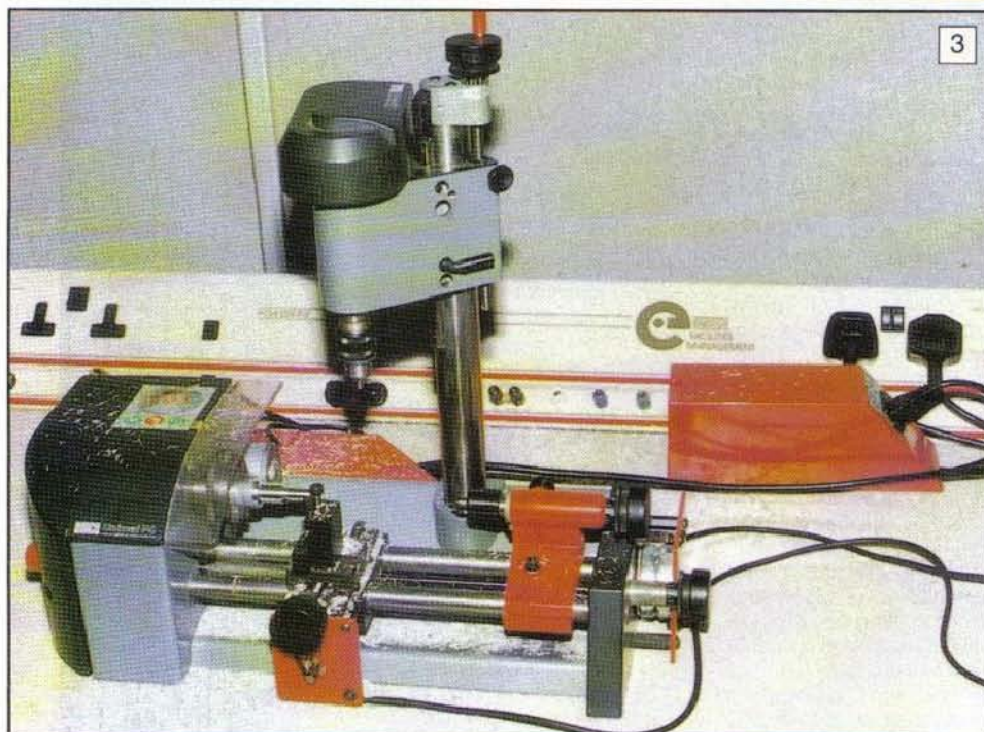
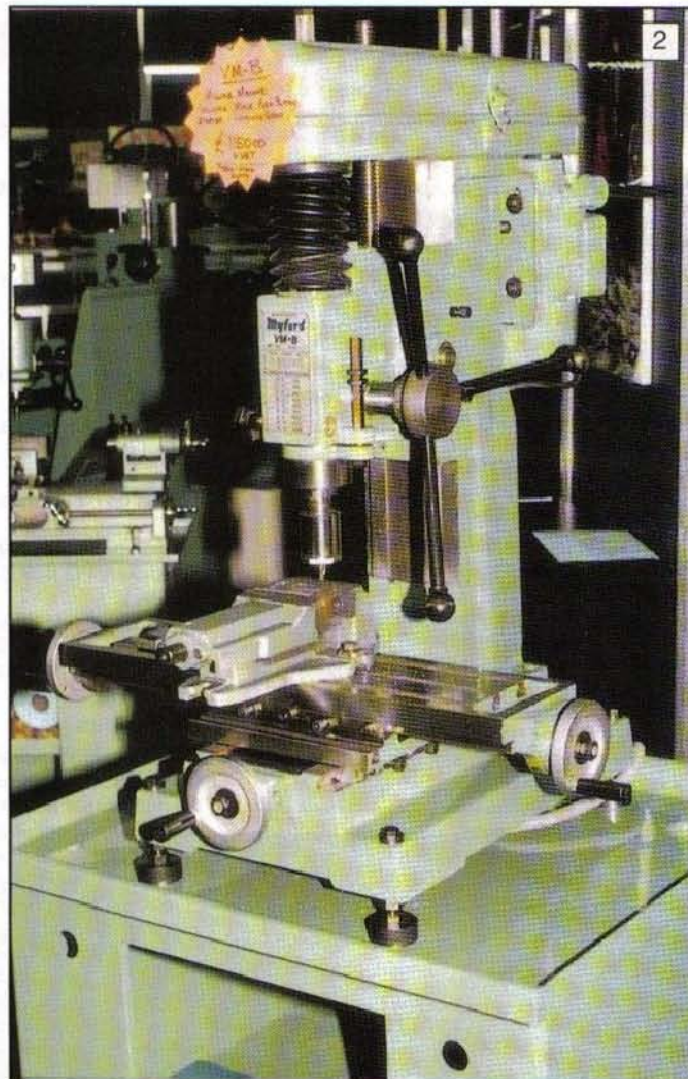
H.S. Walsh, 243 Beckenham Road, Beckenham, Kent BR3 4TS. Tel. 081-778 7061.

8. Silver Steel in long lengths: Acton Bright Steel, Gordon Road, The Causeway, Staines, Midx. TW18 3BG. Tel. 0784 455 273.

They have a minimum order charge of £15.00 inc. VAT for items collected and £25.00 inc. VAT and delivery for items delivered. These prices apply to all forms of steel, so could be a good source of short pieces in larger diameters. They also have an off cuts bin, minimum charge £5.00 collection only. They also state they can supply square silver steel. (Would any reader successful in this direction please let me know? Ed.)



The annual Model Engineer Exhibition at Alexandra Palace, organised by Argus Exhibitions and sponsored by Model Engineer magazine, is the highlight of the model-making calendar. The editor explored this year's show from the home machinist's viewpoint and offers the following illustrated report.



Any first-time visitor to the recent exhibition at Alexandra Palace, will soon become aware that it is more than just a model engineering exhibition as it is frequently referred to. It is, in fact, as its proper title describes it, a Model Engineer and Modelling exhibition, its full title being International Model Engineer and Modelling Exhibition.

The exhibition divides into two main areas, the display models and the trade stands. The models cover a wide range of activities, from those normally considered as model engineering subjects such as traction engines and similar, to others such as cars, ships, planes and many others. For some of these types of models, radio control is also to be seen.

It is not appropriate to discuss models in this magazine, for these the *Model Engineer* and other modelling magazines will have exhibition features.

One competition class which is appropriate to this magazine is that of workshop equipment. This class normally only has a few entries, probably due to most people making workshop equipment for immediate use, and not of a standard usually associated with competition entries.

The section of the exhibition which is

MODEL ENGINEER



1. Unique Sharp Mk II universal milling machine on the Town Bent stand.
2. The new Myford VM-B milling machine.
3. The Emco Unimat PC, this one fitted with stepper motors for CadCam control, hence the cables.
4. The excellent Hobbymat MD65 lathe.
5. The Rishton range of high quality milling machines.
6. The Minilor TR-1 lathe and milling head displayed on the Hegner stand.
7. The Emco Maximat Super II fitted with digital readout.



most definitely of interest to readers of this magazine, including the 45% who have no active involvement in modelling, is the trade stands.

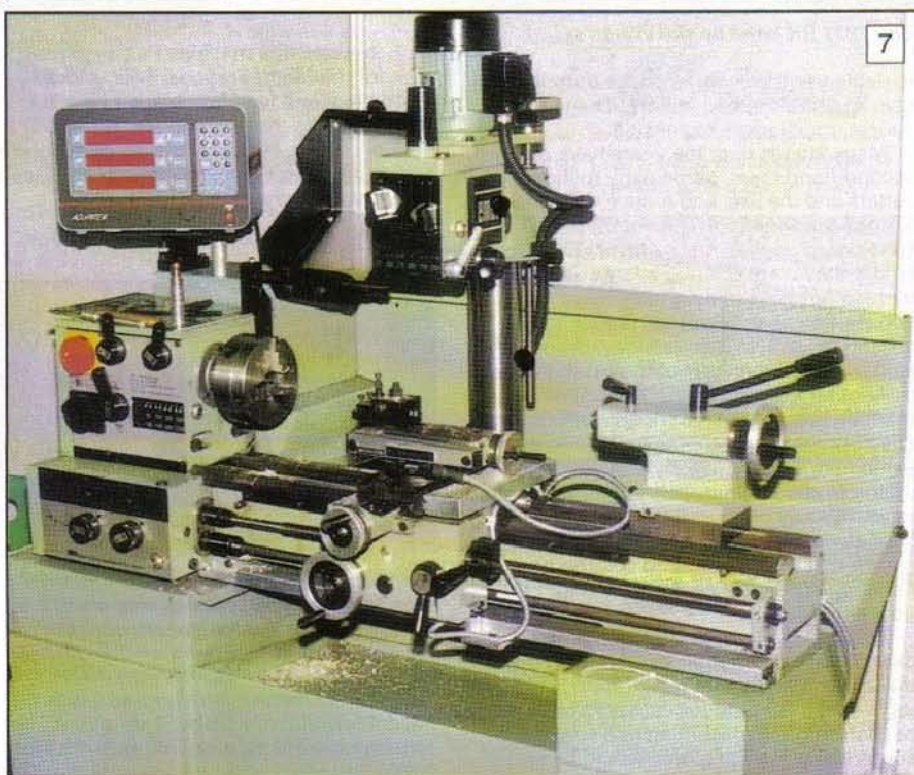
Here again the spread of goods on offer ranges from engineering type machines, tools and materials, to those required for the other branches of modelling. It is the machines and tools for engineering type activities which are briefly reviewed in this article.

Firsts

I have been attending the exhibition as a visitor on a fairly regular basis for about fifteen years, and for some forty years on less frequent occasions. On this basis impressions of firsts are mine, and may be proved to be incorrect by those more knowledgeable.

One item not seen at the exhibition before, but becoming more in evidence in the pages of this magazine, are single to three phase convertors. These enable machines (probably second-hand industrial types) fitted with three phase motors to be run on single phase domestic supplies.

Two companies showing this type of equipment were **MSR Power Engineering** and **ND Electrical**. Both companies had a range of equipment, which more than covered the requirements for the home workshop. ND Electrical could also supply, but were not exhibiting, single phase invertors. These take an input from the single phase mains, converting this to a



EXHIBITION 1992



Some of the milling machines on the Warco stand.



Some of the milling machines on the Excel stand.



The 1327 BH lathe on the Warco stand.

variable frequency three phase output to give a variable speed feature. They are, of course, much more expensive.

Many stands over the years have offered second-hand tools, particularly milling cutters and the like, and maybe occasionally a small machine tool. But another first I consider to be that, on the **Intercity** stand, where they were offering a large second hand lathe and a milling machine. The lathe, a Colchester Bantam, would be around 6in. x 30in. between centres, was sold on the second day of the exhibition.

Another first, though in a different manner, and for me the most significant development in machines on offer at the exhibition, was the VM-B milling machine on the **Myford** stand. This at first sight was much like any other mill/drill on offer. It soon became apparent with a second glance that the usual round column had been replaced with a casting having dovetail slides.

This has two very definite advantages over the usual mill/drills presently on offer, these being firstly that registration is not lost when it is found necessary to raise the head during the machining of a single component. Typical of this would be first marking out a hole using a centre drill, then requiring to raise the head to use a longer drill.

The second advantage refers to the usual method of allowing the down feed to fall under its own weight, making positioning somewhat imprecise, (see *Scribe a Line*, 'Snatchy Milling', Dec/Jan issue. Ed.)

In this case the machine has a normal quill for drilling operations. This is locked for milling, and feed is achieved by a lead screw moving the head up and down the dovetail slides. In theory the same problem could exist, but is probably much less likely due to the weight of the head being moved.

The most important parameters for this



One of the very impressive sets of accessories for the Minilor lathe.

machine are table size 495mm x 150mm. Table travel 366mm, cross travel 146mm head travel 203mm. Spindle speeds: 9 speeds from 195 rpm to 2340 rpm. Motor 0.37KW (1/2HP).

Machines

New machines and major changes to existing machines are not a frequent occurrence, and most manufacturers were displaying their established range of machines.

Two manufacturers of milling machines only, were **Rishton** and **Town Bent Engineering Co.** The Rishton range of very high quality milling machines contains one particularly interesting machine, their Promill-35. This is a small machine, table size 350mm x 130mm.

The main feature of this machine, other than its quality, is the variable speed drive system which gives a speed range of from 200 rpm to 2500 rpm. This is achieved by fitting a three phase motor, but powering this via a single to three phase variable frequency inverter. The motor power is 0.25KW.

Town Bent Engineering Co., provide, to my knowledge, the only truly universal milling machine of appropriate size and cost for the majority of home machinists. Known as the Sharp MK II, this machine has a table size of 20in. x 4 1/2 in., spindle speed ranges of 60 to 600 rpm horizontal and 180 to 1800 rpm as a vertical miller. It is fitted with a 1/2HP motor.

This machine is well worth considering as the horizontal mode will permit some operations to be carried out much more easily. Both Rishton and Town Bent are British made machines.

Emco Maier were displaying a wide range of lathes, from their Unimat PC to much larger machines. The Unimat PC is a 54mm centre height 196mm between centres lathe of unusual design, having electronic speed control to give a very wide speed range of 20 to 2200rpm, the lower speed not normally obtainable on other lathes of similar size.

Most if not all of the lathes can be fitted with milling heads to create complete machining centres. Alternatively, in some cases, the milling head can be fitted to its own compound table to provide a self-contained milling machine. These though were not much in evidence on the stand.

Hobbymat were displaying their small

The Cowells vertical milling machine and 80 CW lathe, both with electronic speed control giving 0-4000 r. p. m.





The Chronos stand was typical of many, packed with countless small tools.

but eminently suitable range of machines for the home machinist. The MD65 lathe, together with separate mill/drill, make a particularly good combination for the engineer looking for complementary machines, towards the smaller end of the range. The Mill/Drill head can also be fitted to the MD65 lathe to make it into a machining centre.

The well established lathes and milling machines on display by **Cowolls** are of proven traditional design, that is at least for larger machines, but are almost unique at this size, and are made to a very high standard.

Another established machine is the **Peatol** micro lathe; this is far from traditional, but still very usable by the machinist who requires to produce small size components. Its very reasonable price makes it an ideal second lathe for those who own a larger machine, but would like something for the smaller parts that sometimes require to be made.

Hegner U.K. were displaying, for the first time by them, the Minilor TR-1 lathe, a 65mm centre height 350mm between centres screw cutting machine. The FR-1 milling attachment is available to turn the lathe into a complete machining centre. Two very impressive boxes of accessories are also available.

The company with the largest range of machines on display was **Warren Machine Tool Ltd.**; their range of machines represents the upper quality end of machines from far eastern sources and are well worth investigating.

Three companies exhibiting a very wide range of machines and accessories, and small tools mostly from far eastern manufacturers, were **Excel Machine Tools**, **Draper Tools Ltd** and **Graham Engineering (Midlands) Ltd.** These have some excellent value-for-money items.

Small tools

A number of retailers of quality small tools exhibited, and who also supply smaller machines such as the Hobbymat MD 65 lathe.

These were, **Chronos Ltd.**, who whilst still providing for the clock making enthusiasts, are now very much into providing for a wider range of activities. **Mill Hill Supplies** have a wide range of top quality small tools, and also import the Toyo ML210 lathe. **Rotogrip Ltd** have a wide range of machine accessories, chucks, collets, angle plates and many other

precision tools.

Shesto Ltd. were the supplier with the largest display, having a particularly wide range of small hand tools.

The stands where small tools were being sold were, without doubt, the most busy and very difficult to gain access to. These were selling tools both new and surplus stock - those selling such items as end mills, drills taps, etc., were particularly busy.

These suppliers were **Asset Glen Ltd.** with a particularly wide range of items as also had **Brick Lane Precision Tools**



Drawing equipment on the Cox Instrument stand; board in foreground is a good buy for the home machinist who wants to commit his designs to paper.

and **Tools UK**. Another very well known supplier in this group was **Tracy Tools Ltd.**, exhibiting their wide range of reasonably priced taps, dies, drills and end mills, etc.

Sumitomo Electrical Hardmetal Ltd. were displaying a range of modern material tooling inserts, these for use on either lathe or milling machine.

Expo (Drills) Ltd., were showing their range of British low voltage drills. Other largely British-made items could be seen on the **Verdict Gauge** and **Gabro** stand, now sharing the same stand as they are part of the same group. Verdict, with their very well known range of dial indicators and Gabro with a range of sheet metal equipment, the model 2M2 guillotine/notcher being particularly interesting. **Microflame** were exhibiting the very wide range of 'Dremel' small power tools, both hand drills and small machines. This includes, fretsaws, circular saws and many others.

Materials

Five exhibitors predominantly fell into



The only thing not on the Graham Engineering (Midlands) Ltd., display was spare space!

the category of material suppliers: they were **Blackgates Engineering**, **GLR Distributors Ltd.**, **Maidstone Engineering Services (Sales)** and **AJ Reeves and Company (Birmingham) Ltd.** These four, in addition to stocks of raw materials, also supply castings for workshop equipment.

The fifth supplier was **College Engineering Supply** who, whilst having a range of raw materials, have a particularly wide range of castings for making workshop equipment.



This small CNC milling machine made by Michael J. Franklin won a Silver Medal.



Another Silver went to C. R. Studer for this lovely Quorn cutter grinder.

Drawing equipment

Three exhibitors were displaying drawing aids but, for the home machinist who would like a drawing board complete with drafting machine, the 500mm x 750mm table mounted board at around £160.00 on the **Cox Instrument** stand looked a very good buy.

Miscellaneous

Zip Tools displayed predominantly a range of electrical items including some small electric motors.

For a range of books on modelling and home machining no one has a wider range than **TEE Publishing**. In addition to those published by **Argus Books** they have a large number of books from other sources, many from the USA.

One book which caught my eye was *The Home Metalworker* by Julian Worthington, a hard back A4 size book with over 100 pages, and extremely well illustrated in colour. This covers both hand and machine

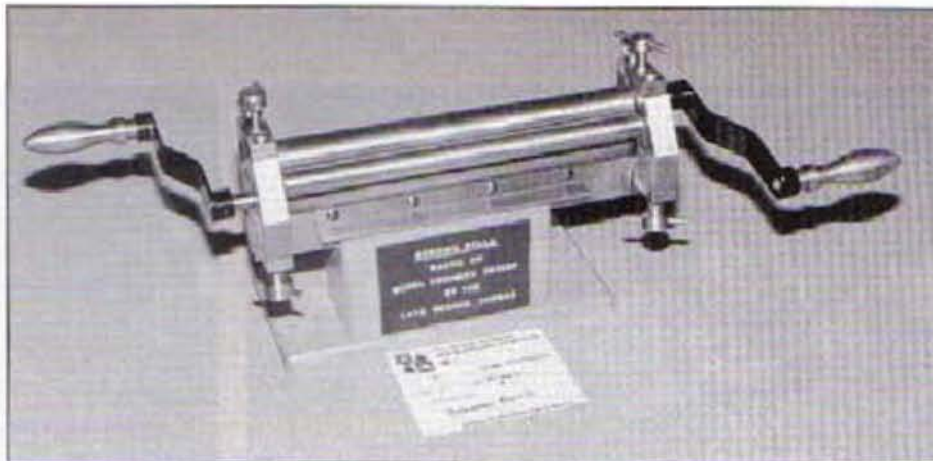


A rotary table made by Allan Turner of Northorpe.

work, being biased towards a beginner's level and, at £2.95, looks a bargain buy.

Conclusions re trade exhibits

This brief round up of items of interest to readers of this magazine is, of course, incomplete. Many exhibitors do not just fit into the category I have placed them in, and will have on offer a wider range of items. Most will provide catalogues, and the accompanying list will enable contact to be



Well made bending rolls made by John Nicholson of Bingley.

made with them by phone or post. Please mention **MEW** in any contact with them!

Competition items: Workshop Equipment

As was stated at the commencement of this article, the Tools and Workshop appliances class of the competition was not that well supported. This is perhaps not surprising, as most will be making their items of workshop equipment with a view to putting them to immediate use. Perhaps in future there could be a display, rather than a competition of items to exhibit their usefulness...

One item of particular interest was a small milling machine made by **Michael J Franklin** of Kettering. This was fitted with stepper motors on all three axes and

controlled from a BBC PC to give full CNC control. In all there were about 15 items in this section, a few of which can be seen in the displayed photographs.

Next year's Exhibition

I do hope this round-up of the Exhibition will have been of interest, particularly to those who were unable to attend. Perhaps this may have prompted those of you who live close enough to consider visiting the Exhibition next time. If nothing else, this will enable you to participate in the many genuine bargains that are always available. These are evident by the large number of visitors around the stands supplying small tools.

M.E. Exhibition Trade Exhibitors of interest to readers

Asset Glen Ltd

New Portreath Road, Bridge, Nr. Redruth, Cornwall TR16 4QL
Tel: 0209 843 656

Blackgates Engineering

209 Wakefield Road, Drighlington, Bradford BD11 1EB
Tel: 0532 853652

Brick Lane Precision Tools

81 Adelaide Avenue, Brockley, London SE14 1JY
Tel: 081-690 3538

Chronos Ltd

95 Victoria Street, St. Albans, Herts AL1 3JT
Tel: 0272 832793

College Engineering Supply

2 Sandy Lane, Codsall, Wolverhampton WV8 1EJ
Tel: 09074 2284

Cox Instruments

PO Box 255, Brentwood, Essex CM15 9AP
Tel: 0277 224224

Draper Tools Ltd

Hursley Road, Chandler's Ford, Eastleigh, Hants SO5 5YF
Tel: 0703 266355

Emco Maier Ltd

10 Woodshots Meadow, Croxley Centre, Watford WD1 8YZ
Tel: 0923 50051

Excel Machine Tools

Brindley Road North, Baxton Road Industrial Estate, Exhall, Coventry CV7 9EP
Tel: 0203 3665255

Expo (Drills) Ltd

Clock Tower Works, Warsash, Hants SO3 6FH
Tel: 0489 885166

Gabro (See Verdict)

Graham Engineering (Midlands) Ltd

Alpine House, Roebuck Lane, West Bromwich, West Midlands B70 6QP
Tel: 021 515 3133

GLR Distributors Ltd

Great Northern Works, Hartham Lane,

Hertford, Herts SG14 1QN

Tel: 0922 552962

Hegner UK

Wymondley House, Ersham Road, Hailsham, East Sussex BN27 3LE
Tel: 0323 442440

Hobbsmat

1 Elstree Way, Borehamwood, Herts WO6 1NH
Tel: 081-953 1688

Intercity Machine Tools (HW) Ltd

Lindsay Avenue, High Wycombe, Bucks HP12 3ER
Tel: 0494 33211/2/3

Maidstone Engineering Services (Sales)

50 Hedley Street, Maidstone, Kent ME14 5AD
Tel: 0622 691308

Microflame Ltd

Vinces Road, Diss, Norfolk IP22 3QH
Tel: 0-379 644813

Mill Hill Supplies

66-68 The Street, Crowmarsh, Gifford, Nr. Wallingford, Oxon OX10 8ES
Tel: 0491 38653/25518

MSR Power Engineering Ltd

30 Refern Road, Tyseley, Birmingham B11 2BH
Tel: 021 708 2811

Myford Ltd

Chilwell Road, Beeston, Nottingham NG9 1ER
Tel: 0602 25422

ND Electrical

29-35 Holly Road, Twickenham, Middx TW1 4EA
Tel: 081-892 2722

Peatol Machine Tools

19 Knightlow Road, Harborne, Birmingham B17 8PS
Tel: 021 429 1015

AJ Reeves & Company (Birmingham) Ltd

Holly Lane, Marsden Green, Birmingham, West Midlands B37 7AW

Tel: 021 770 6831

Rishton Machines

Mary Street, Rishton, Blackburn BB1 4RF
Tel: 0254 888001

Rotagrip Ltd

16-20 Lodge Road, Hockley, Birmingham B18 5PN
Tel: 021 551 1566

Shesto Ltd

Unit 2, Sapcote Trading Centre, 374 High Road, Willesden, London NW10 2BH
Tel: 081-451 6188

Sumitomo Electrical Hardmetal Ltd

54 Summerleys Road, Princes Risborough, Aylesbury, Bucks HP17 9PW
Tel: 084 44 2081

TEE Publishing

Edwards Centre, Regent Street, Hinckley, Leics LE10 0BB
Tel: 0455 616419/637173

Tools UK

Unit 1 B/C, Alexandra Road Industrial Estate, Cullompton, Devon EX15 1BW
Tel: 0884 34415

Town Bent Engineering Company

Henry Street, Rishton BB1 4JJ
Tel: 0254 876844

Tracy Tools Ltd

2 Mayors Avenue, Dartmouth, South Devon TQ6 9NC
Tel: 0803 833134

Verdict (and Gabro)

Hilton Road, Cobbs Wood Industrial Estate, Ashford, Kent TN23 1EW
Tel: 0233 622214

Warren Machine Tools Ltd

Warco House, Midleton Industrial Estate, Guildford, Surrey GU2 5XW
Tel: 0483 33361

Zip Tools

Quintonhill Farm, Sewardstone Road, Waltham Abbey, Essex EN9 3QE
Tel: 0992 701274

LATHES

Boxford TF 1020 10" x 20" 3ph £1800.00

Boxford ALO 410" x 18" 1ph fully tool £1250.00

Boxford ALO 410" x 18" 1ph fully tool £1250.00

Boxford BUD 410" x 18" 1ph fully tool £850.00

Boxford BUD 5" x 22" 1ph fully tool £1400.00

Boxford CUD 5" x 22" 1ph fully tool £1250.00

Boxford ALO 5" x 22" 1ph fully tool £1600.00

Colchester Master 610" x 25" 3ph fully tool £2500.00

Harrison 140 3ph fully tool £1000.00

Harrison 140 1ph fully tool £1200.00

Boxford CUD 410" x 18" 1ph fully tool £750.00

Smart and Brown, model L, 3ph, tooling £200.00

Raglan training lathe, 3ph £200.00

Colchester Master 610" x 25" 3ph £1500.00

Colchester Barlow 410" x 25" 3ph £1200.00

Wilson Steel Bed Lathe, 3ph, tooling £750.00

Weyford ML7 & Tooling, 3ph £2750.00

Harrison M250 5" x 30" (see new, unused) £1500.00

Colchester Master 610" x 25" 3ph £1500.00

Colchester Barlow 410" x 25" 3ph £1500.00

DRILLING MACHINES

Outback High speed precision drill £125.00

Hanks Tapping Machine 3ph £600.00

Baymaster 6 Station turret drill 3ph £1500.00

Ensign 4 E M geared head 3MT 3ph £750.00

Richmond SR2 Radial drill 3ph £2750.00

Grinnell Bench drill 2MT 3ph £225.00

Ace tapping machine 3ph £300.00

Middings Articulated Arm Radial Drill Arbor 27" Radial Drill 3ph £300.00

Pollard & Spindle Drill, 3ph £350.00

Pollard Corona Plus, 3MT, 3ph £150.00

Herbert High Speed Bench Drill, 3ph £150.00

Webb High Precision Floor Standing Pillar Drill £350.00

Chick Bench Tapper, 1ph £120.00

MILLING MACHINES

Tom Senior Universal 3ph £1250.00

Tom Senior M1 with Horizontal Turret head 3ph £950.00

Taylor Hobson Engraver, 1ph £350.00

Harrison Horizontal Mill, 3ph £450.00

Parkinson Universal Mill, Well Tooling, 3ph £1000.00

Ward Major Mill/Drill on Cabinet Stand 1ph £650.00

Frederick Deckert Tool room mill, 3ph £750.00

Elliott Minor Turret Mill, 3ph £1600.00

POWER HACKSAWS

Qualters & Smith 6" 3ph £225.00

Manchester Rippler 6", 3ph £250.00

Wetlaw Hackzaw 4", 3ph £175.00

Rucos 18" (Monster), 3ph £1005.00

GRINDERS

Elliott Excel Die Filer 3ph £280.00

Elliott Accumatic B 16 Surface Grinder 3ph needs attention £1450.00

Elliott Excel Surface Grinder mag chuck 3ph £850.00

RHM Radicator on pedestal 3ph £225.00

Wolf DE Grinder 3ph £45.00

Capco Surface Grinder 3ph £850.00

Large Surface Grinder (Unused) £300.00

Harrison Double Ended Polisher, 3ph £120.00

Clarkson tool & Cutter Grinder, 3ph £300.00

Union Jubilee D.E. Grinder 3ph £125.00

RHM Bench Grinder on pedestal 3ph £250.00

Arbora Pad Grinder with Dust Extractor, 3ph £175.00

RHM Bench Linisher, 1ph £75.00

Willow Whippell 5" x 6" Pedestal Linisher, 1ph £180.00

Eagle Hand OP surface Grinder, 1ph £750.00

RHM Pad Linisher, 1ph £205.00

SHAPERS

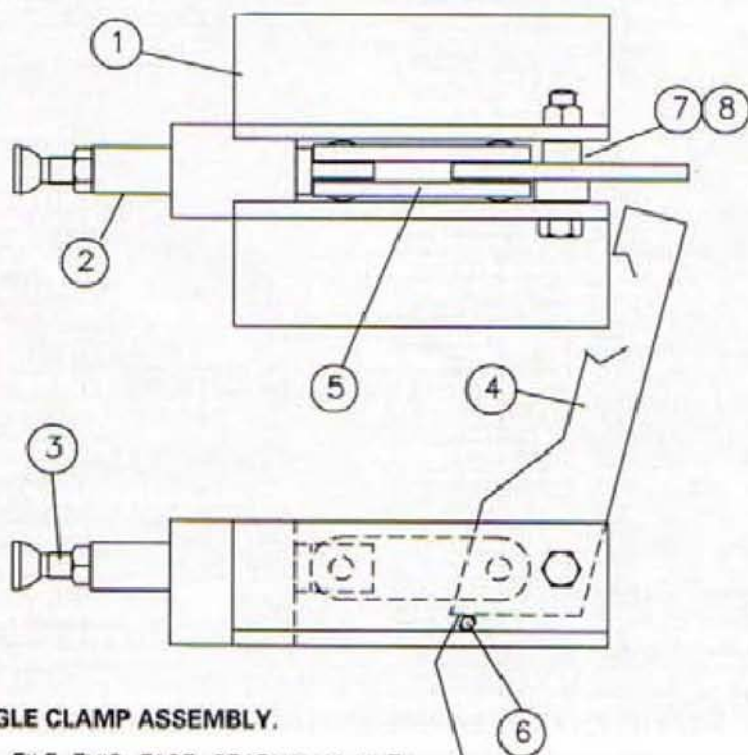
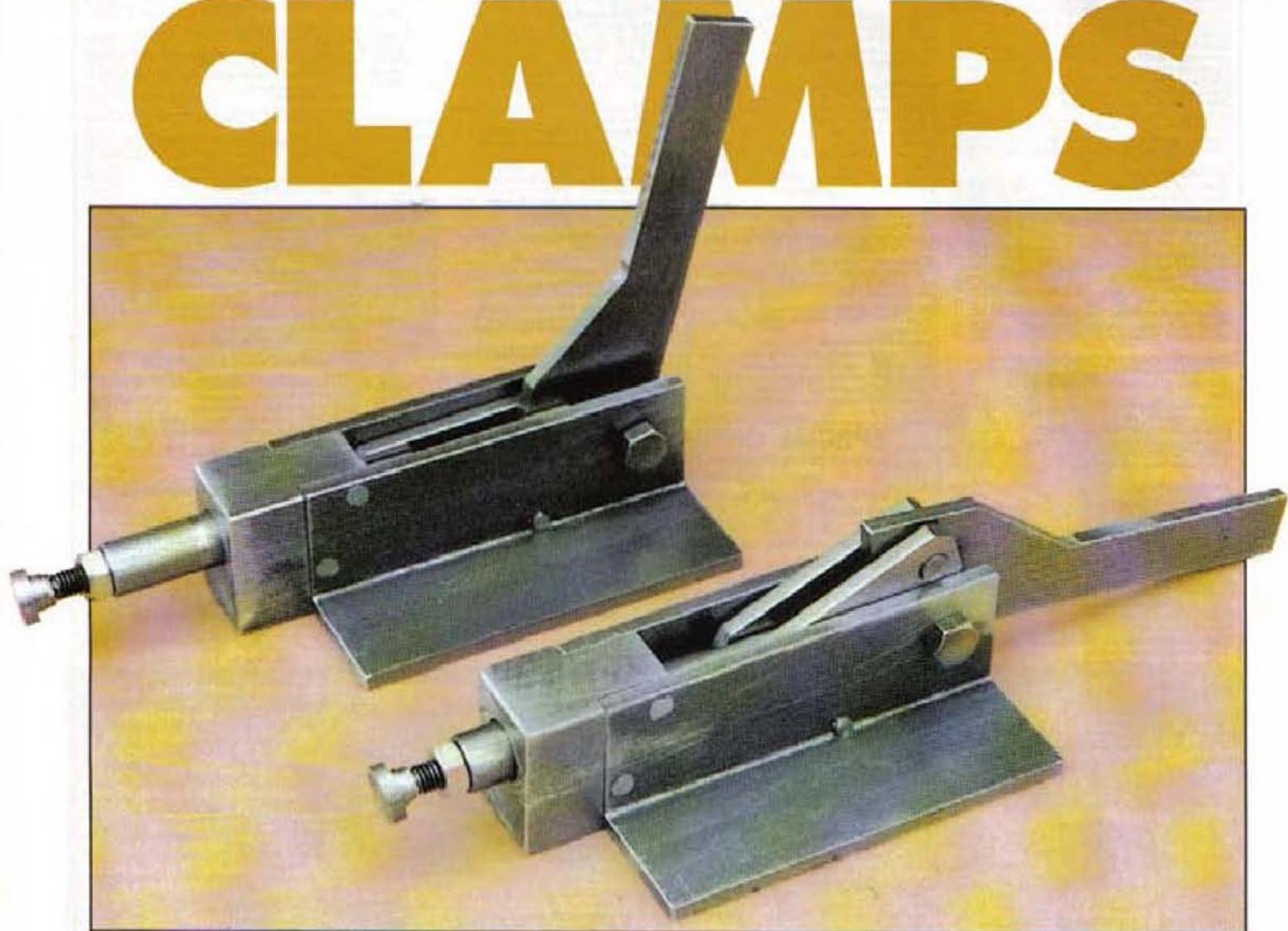
Elliott 108 Shaper, 3ph £200.00

Newey 14" Shaper with Revers Vise, 3ph £200.00

BOXFORD SPARES AND TOOLING

Change Gears (all in Southdown) 180 £10, 180 £11, 201 £11, 211 £11, 221 £11, 231 £11, 241 £11, 251 £11, 261 £11, 271 £11, 281 £11, 291 £11, 301 £11, 311 £11, 321 £11, 331 £11, 341 £11, 351 £11, 361 £11, 371 £11, 381 £11, 391 £11, 401 £11, 411 £11, 421 £11, 431 £11, 441 £11, 451 £11, 461 £11, 471 £11, 481 £11, 491 £11, 501 £11, 511 £11, 521 £11, 531 £11, 541 £11, 551 £11, 561 £11, 571 £11, 581 £11, 591 £11, 601 £11, 611 £11, 621 £11, 631 £11, 641 £11, 651 £11, 661 £11, 671 £11, 681 £11, 691 £11, 701 £11, 711 £11, 721 £11, 731 £11, 741 £11, 751 £11, 761 £11, 771 £11, 781 £11, 791 £11, 801 £11, 811 £11, 821 £11, 831 £11, 841 £11, 851 £11, 861 £11, 871 £11, 881 £11, 891 £11, 901 £11, 911 £11, 921 £11, 931 £11, 941 £11, 951 £11, 961 £11, 971 £11, 981 £11, 991 £11, 1001 £11, 1011 £11, 1021 £11, 1031 £11, 1041 £11, 1051 £11, 1061 £11, 1071 £11, 1081 £11, 1091 £11, 1101 £11, 1111 £11, 1121 £11, 1131 £11, 1141 £11, 1151 £11, 1161 £11, 1171 £11, 1181 £11, 1191 £11, 1201 £11, 1211 £11, 1221 £11, 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HORIZONTAL TOGGLE CLAMPS



TOGGLE CLAMP ASSEMBLY.

FILE THIS FACE GRADUALLY UNTIL
CORRECT TOGGLE ACTION IS ACHIEVED

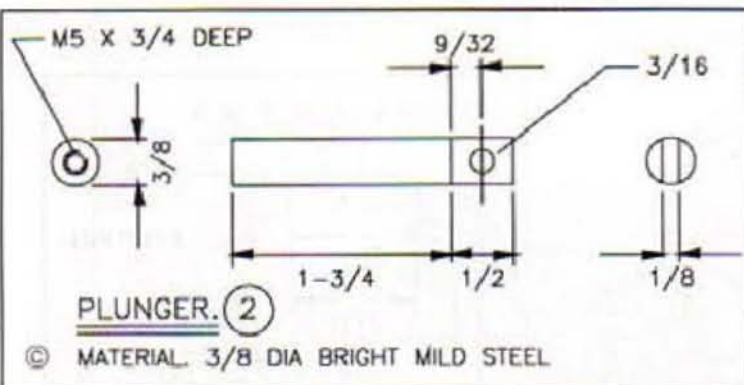
The finished items; for a completely professional touch, heat shrink handle grips will be added . . .

In this second article on toggle clamps we offer a design for a horizontal clamp, a very useful alternative to the vice, particularly where the items to be held are larger than can be accommodated in the vice available

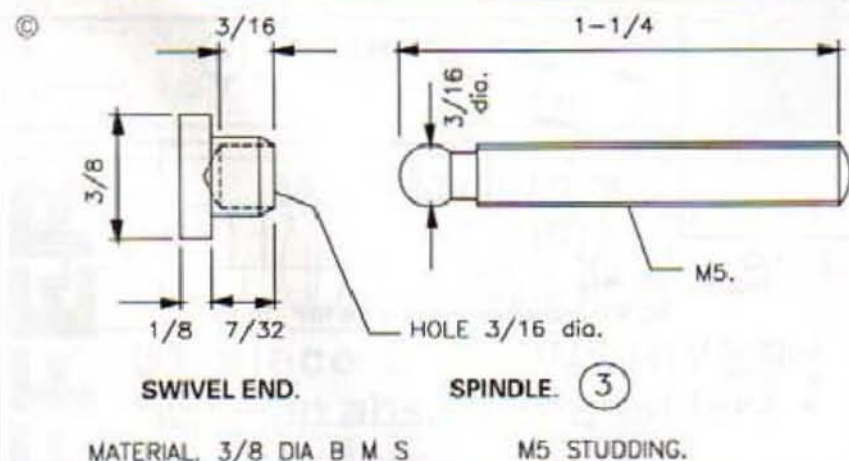
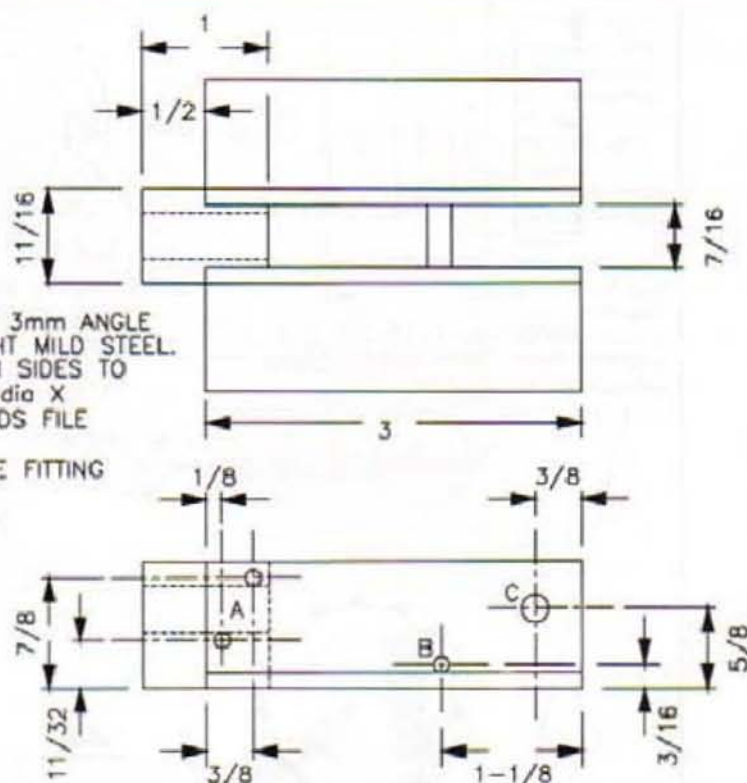
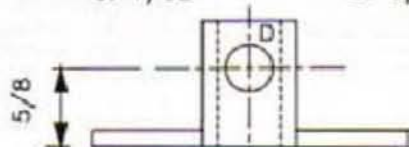
In this second and concluding article on toggle clamps we have a horizontal clamp. There is no theoretical reason why the design for the vertical clamp could not just be swung through 90 degrees. It is, though, more practical to use a plunger clamping action, rather than the pivoted action used on the vertical type.

The clamping mechanism for the horizontal type is simpler than that for the vertical clamp, having only three hinge pins as opposed to four. Another feature is that the actual toggle is directly in line with the clamping pressure.

Model Engineers' Workshop



NOTE. MADE FROM 25mm X 25mm X 3mm ANGLE
1 X 1 INCH BRIGHT MILD STEEL.
HOLES. A. 2 HOLES 3/32 CSK BOTH SIDES TO
1/8 dia. FIT PINS 3/32 dia X
3/4 LONG AND RIVET ENDS FILE
FLUSH
B. 1/8 FIT STOP PIN BEFORE FITTING
PINS A AS ABOVE
C. 7/32 D. 3/8



Manufacture

Manufacture conforms very closely to that detailed in the last issue, but there are a few points worthy of mentioning.

The base side angles are riveted onto the plunger block; but do ensure the stop pin is fitted first before riveting. The stop pin does not require to be riveted, as the operator bearing fitted with a M5 screw, provides all the strength required at that end. Do ensure that the central part of the stop pin is the same length as the width of the narrow portion of the plunger block.

The bearing should be made after the base assembly has been riveted together, this so it can be made a close fit between the side plates. With this done, it will prevent any unnecessary strain being placed on the rivets, through the plunger block.

The method of fixing the bush into the operator was used more as a point of interest, rather than a necessity. The bush could be left loose, and an additional loose bush placed on the small end to keep the operator central.

To ensure success with the method as drawn, for fitting the bush into the operator handle, the bush must be made a very close fit in the hole in the handle. With this done there should be no problem in

making it captive. Do this by using a centre punch all round the bush, and as close to it as the punch will permit.

In the case of the vertical clamp all hinge points are riveted, and the resulting assembly can then not be dismantled. The horizontal clamp though requires only the hinge pin for the links onto the operator to be riveted, as the pin through the links and the plunger is retained by the base side plates. The M5 screw of course can be removed to allow the toggle assembly to be separated from the base if required.

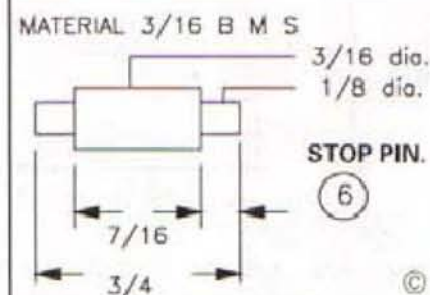
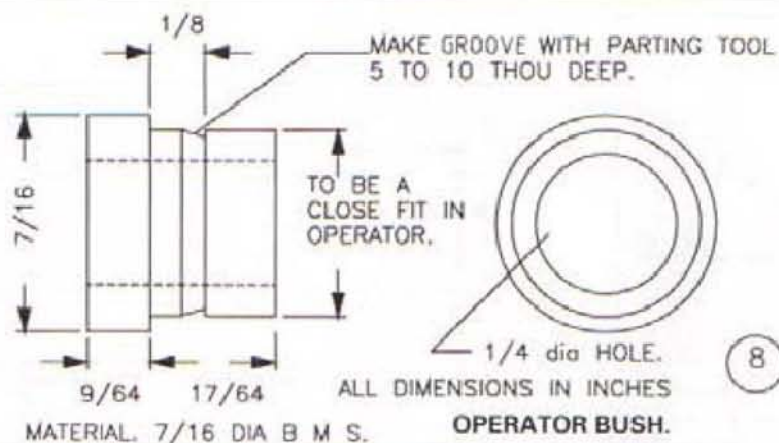
Achieving the correct latching action is done by removing metal from the front lower corner of the operator, where it locates with the stop pin. Do this gradually until a sufficiently secure action results.

When complete, check to establish if the base is adequately flat, if not lightly machine the base all over to achieve a satisfactory result.

This form of toggle clamp can easily be adapted to make a small press, by making a more robust version and mounting it in the vertical mode, on an angle plate.

**A pair of finished bases;
material is bright
mild steel.**

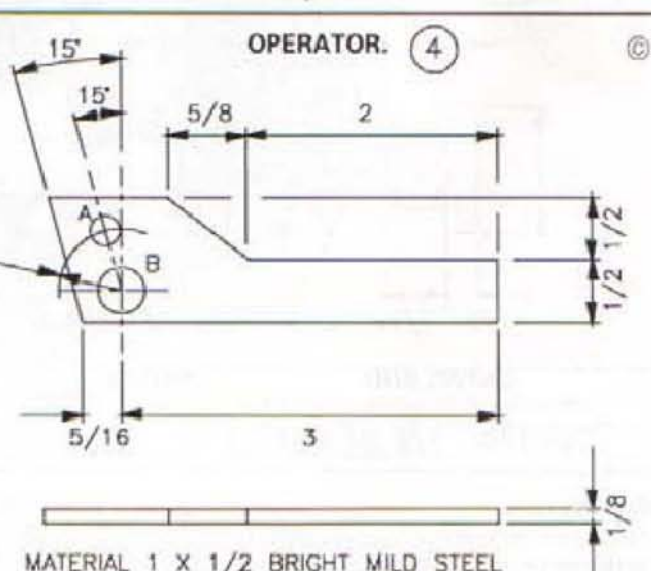
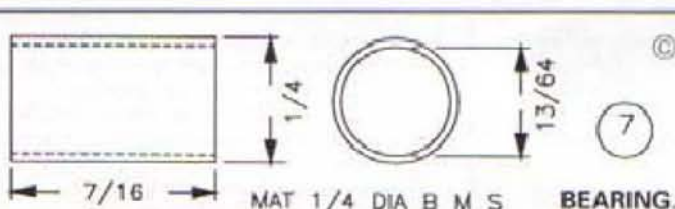
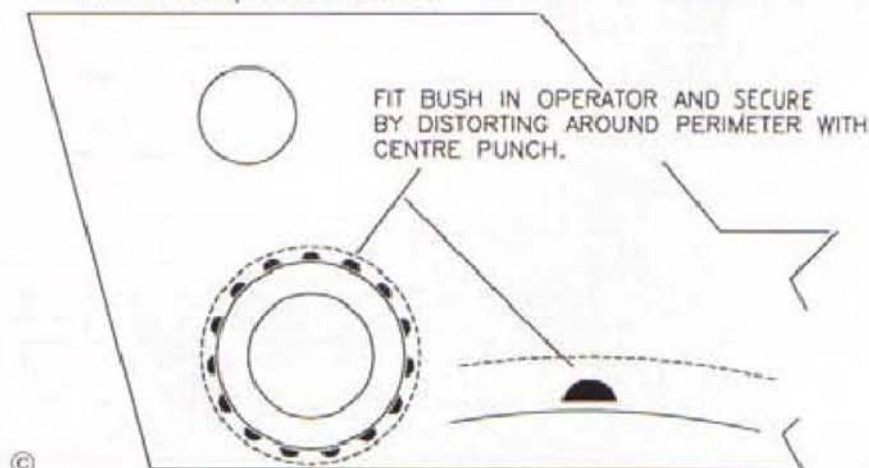




Heat shrink

A nice way to finish off the handles of this, and those of the vertical clamps in the previous issue, is by using heat shrinkable tubing. This useful material is unfortunately not that easy to come by, but Tandy (the high street electronic stores) do supply a small pack containing assorted sizes up to 1/2 inch diameter (shrunk size), their part No. 278-1627, and costs around £2.

This is normally shrunk using a hot air blower, but the normal hairdryer is not hot enough. I find that holding the item and rotating it just above the opening of a toaster, shrinks the tubing very well, as a result of the rising heat. Do not be tempted to place the item into the slot to speed up the operation! Another tool in many DIY kits is an electric paint stripper. These, kept on the move, are super for the job.



Material list

The following lists the main materials required but does not include the round materials which it is assumed will be available.

15 inches off: 25mm x 25mm x 3mm bright steel angle

8 inches off: 1 inch x 1/2 inch bright mild steel

8 inches off: 1/2 inch x 1/2 inch bright mild steel

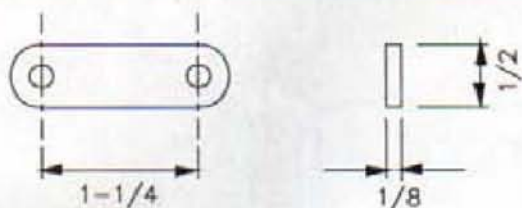
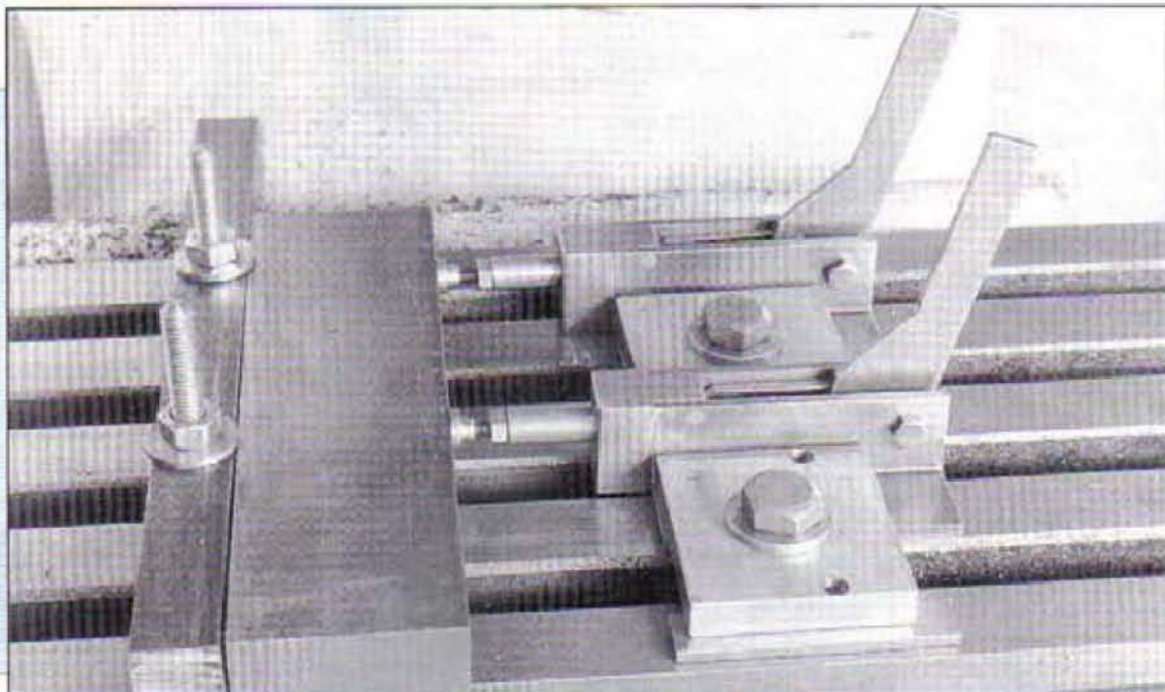
QUICK TIP

From time to time most of us have acquired bits of material, often in bargain lots, of rather unknown quality. Steel in particular is very variable. Before putting effort into machining the unknown the following will give an indication of machinability. Does the material cut easily with a hacksaw? If centring a bar does the centre drill cut freely and give a spiral of swarf? If the answer to either is no then give up at that stage if complex accurate machining is required. Carbon steels may be tough to work but may machine OK. They will give a fireworks display when touched on a grinding wheel.

John Jennings

One horizontal toggle clamp - as a kit of parts.





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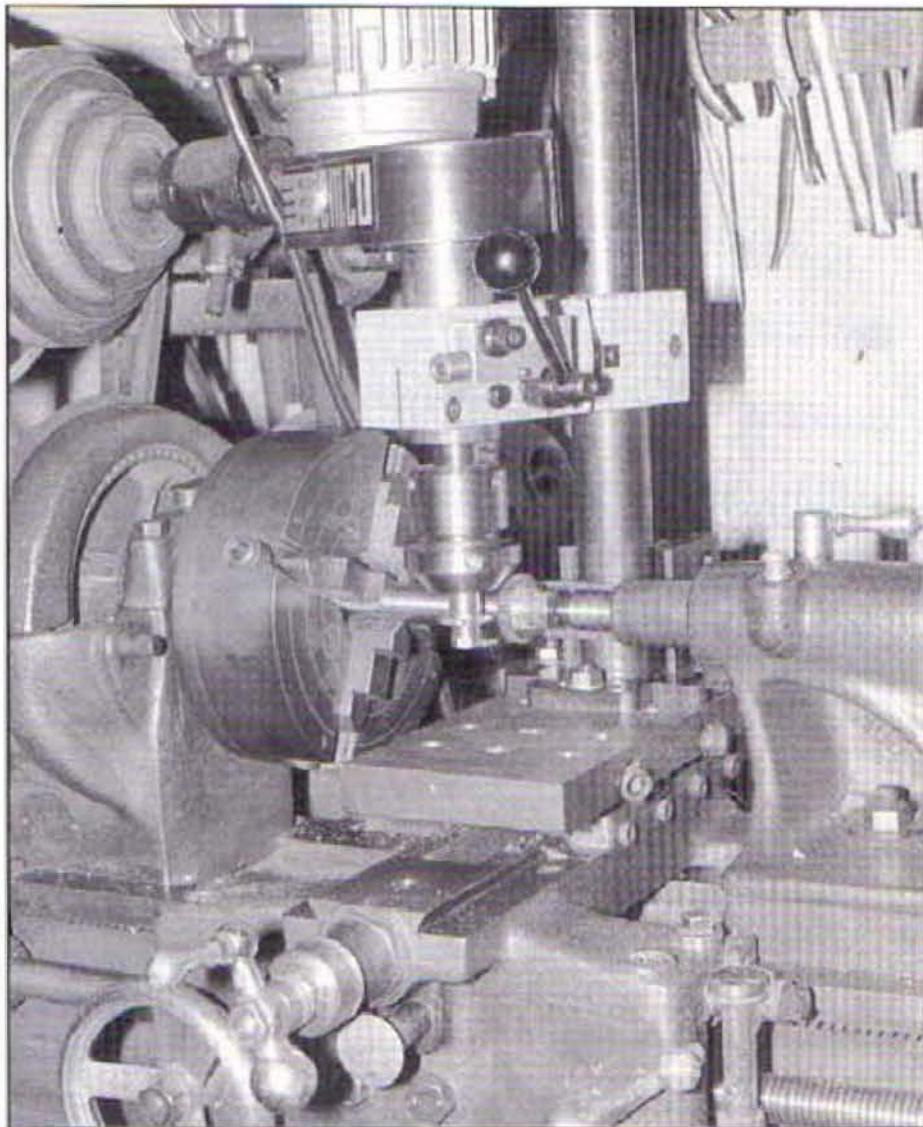
In this, the final article on attachments for the Toyo lathe, Mr Winks shows how to construct the required components to enable screw cutting to be carried out on this excellent little lathe. We thank Mr Winks for this series of articles

Screwcutting gears

The general arrangement is similar to the manufacturer's own set, using a toothed belt to transmit the drive to the first changewheel on the quadrant (1). The pulley on the mandrel has 18 teeth, the one (10) on the quadrant has 18 teeth for metric threads or 17 teeth for inch threads. The leadscrew pitch is 1mm, i.e. 25.4 threads per inch. Thus, if the changewheel ratio is unity, with a 17-tooth pulley on the first wheel the effective leadscrew pitch becomes $25.4 \times \frac{17}{18} = 23.99$ T.P.I., which is near enough to 24 T.P.I. for most practical purposes.

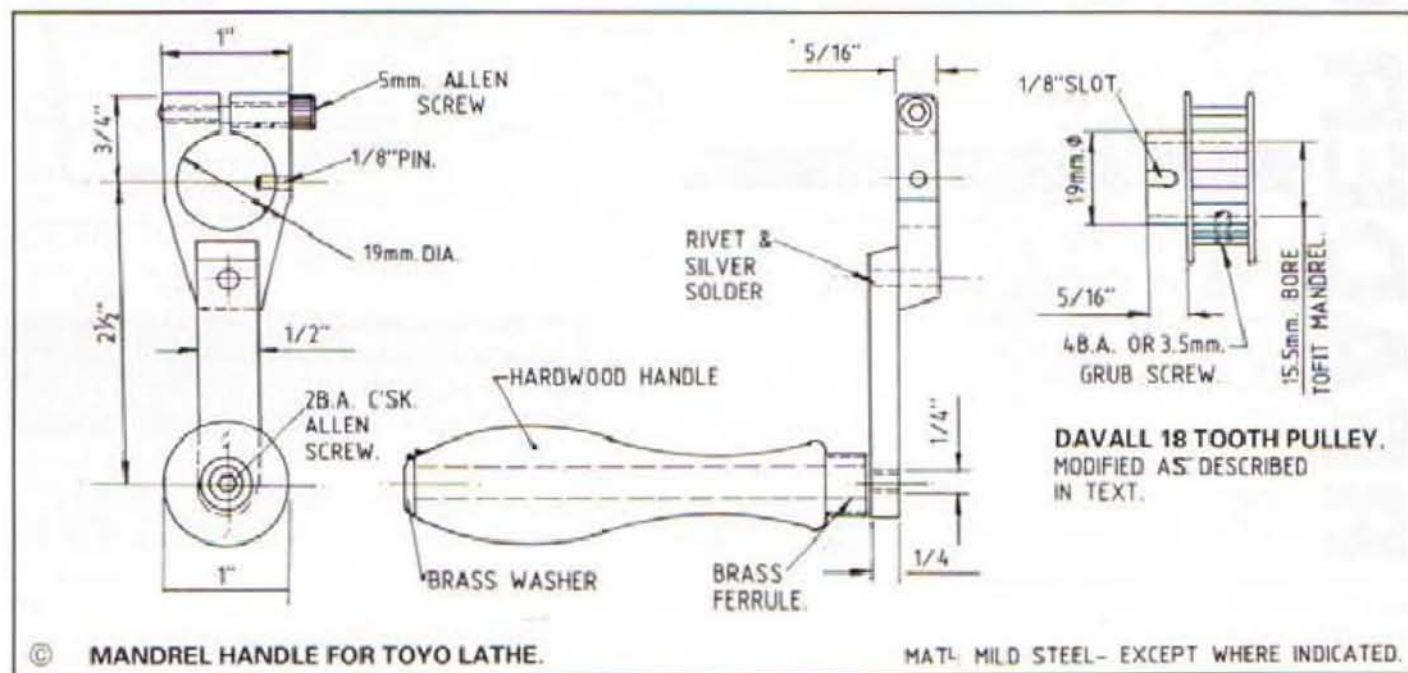
The changewheels were made in the sequence - 32, 36, 39, 40, 42, 48 (2 off) 60, 64, 72, 80. This will provide a good range of inch and metric threads (see **tables 1** and **2**) and has the advantage that all can be cut by direct division with the Chronos DD 62 division plate.

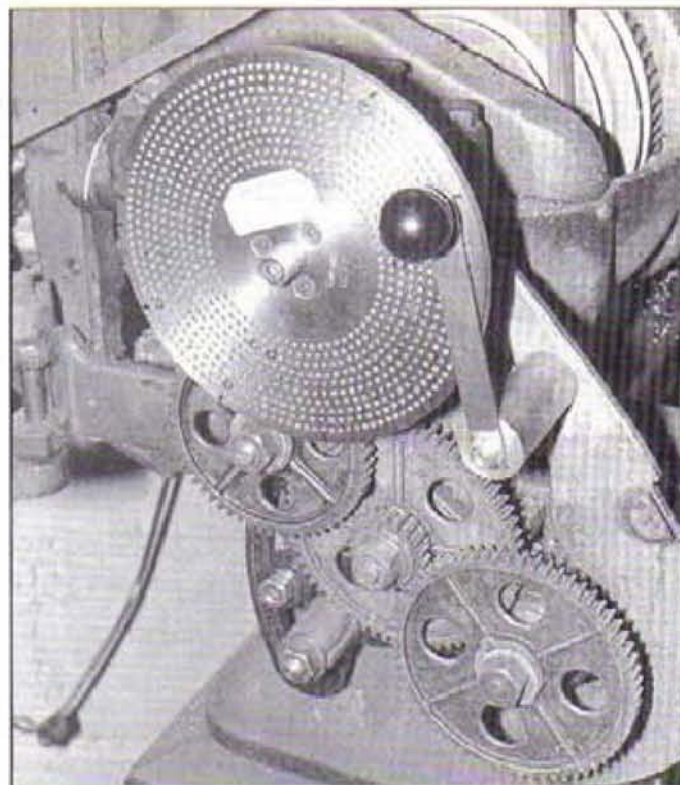
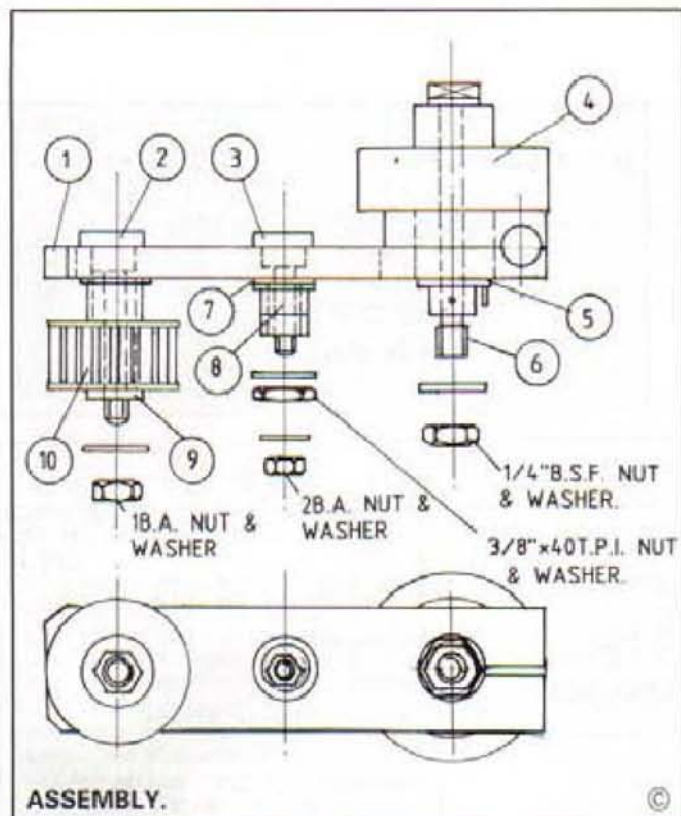
It is of course normal practice to use the involute tooth form for lathe changewheels, but I was unable to find an economical source of supply for involute cutters of a suitable small size for use with the equipment available, so I used a horological wheel cutter from Thorntons. I chose the fairly fine pitch of 0.6 Module, so that the smallest wheel has 32 teeth.



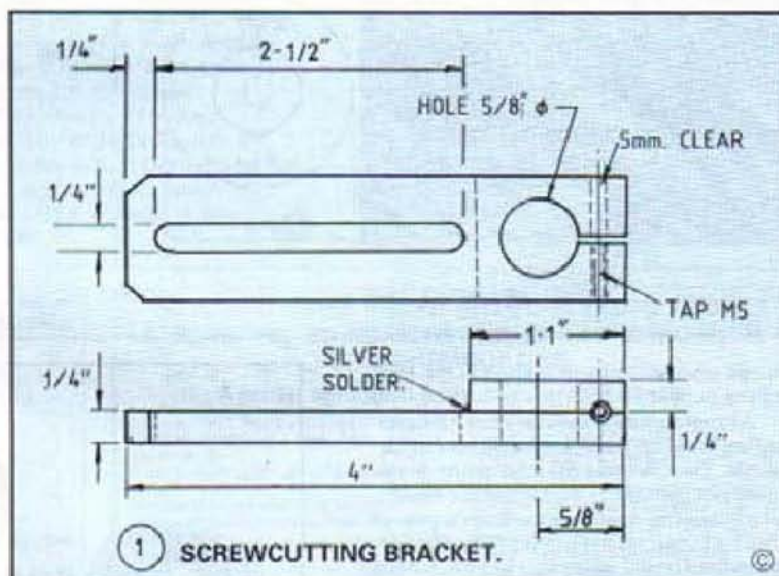
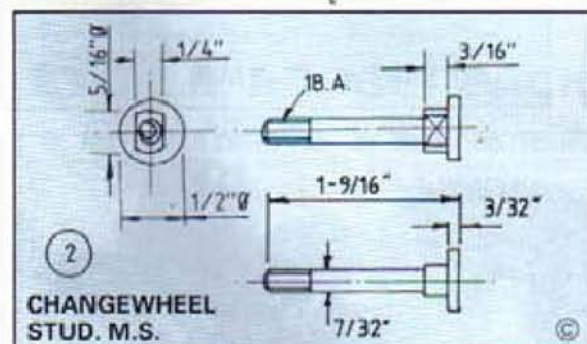
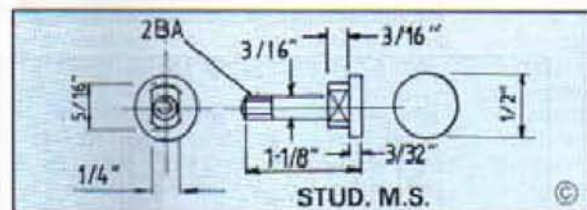
Set-up for cutting the screwcutting gears.

SCREW CUTTING ON THE TOYO





Division plate for gear cutting.



Although the tooth form must be theoretically incorrect on the smaller wheels, they work perfectly well in practice. As speeds and tooth loading are low in this application one can get away with quite a lot.

The gearcutting was done on the 5in. Atlas lathe, using the column and head of an Emco Compact milling machine mounted on the lathe cross-slide by means of a Keats angle plate, with the division plate mounted on the tail of the mandrel by the usual expanding plug. **Photos 1 and 2** show the set-up. The wheels were made of brass, $\frac{1}{16}$ in. thick, for ease of cutting. The smaller blanks were parted off from 35mm bar, the larger ones cut from 2in. x $\frac{1}{4}$ in. flat. The bores of the wheels were reamed $\frac{1}{16}$ in. The literature provided by the cutter maker gives formulae for calculating the blank diameters and depth of feed so I will not repeat it here.

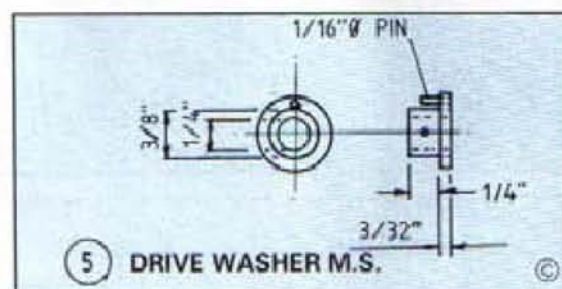
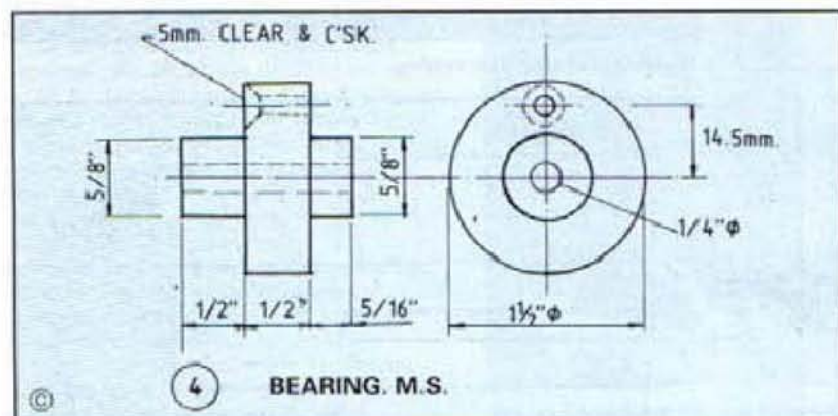
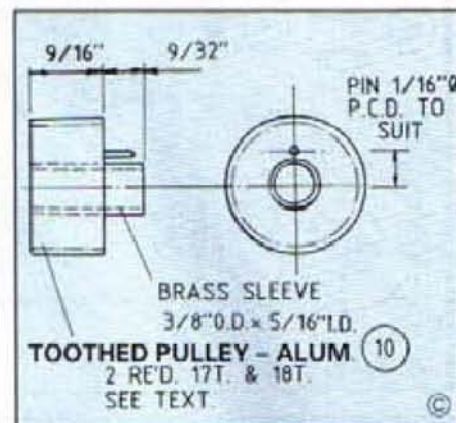
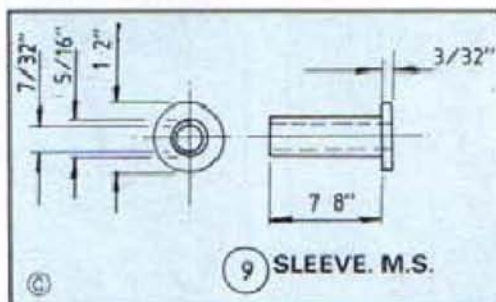
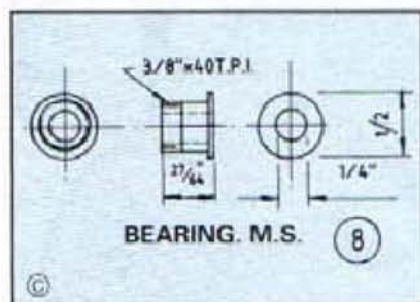
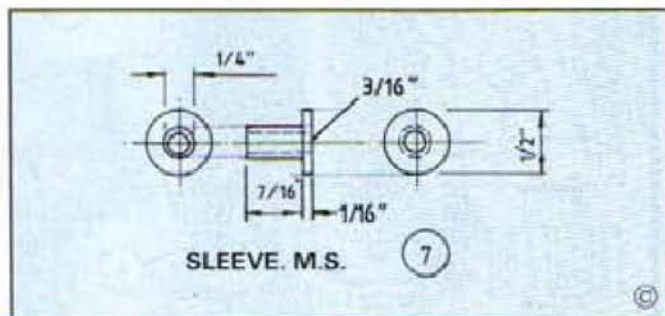
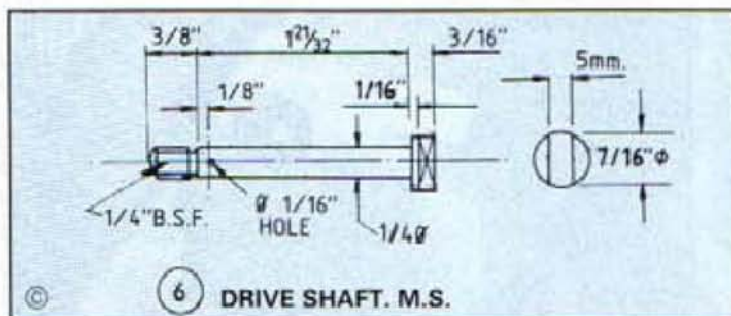
The two 18 tooth pulleys and a 90 tooth belt were purchased from Davall Stock Gears Ltd. The stock numbers are 18XL037 and 90XL037 respectively. They do not list a 17-tooth pulley so this had to be made as

described below.

The screwcutting components are shown in **Photos 3 & 4**. The bracket is a 4in. length of 1 in. x $\frac{1}{4}$ in. flat steel with a 1.1in. length of the same material silver-soldered to one end to form the clamping boss, which is bored $\frac{1}{16}$ in., slotted and fitted with an M5 Allen screw. A slot $\frac{1}{4}$ in. wide and 2.5in. long is slot-drilled along the centre of the bracket for mounting the changewheels. The bracket is connected to the headstock by a steel boss. The centre section of this is 1.5in. dia. & $\frac{1}{2}$ in. long, with a $\frac{1}{16}$ in. dia. spigot at each end. The outer spigot is $\frac{1}{2}$ in. long, on which the bracket is clamped. The inner one is $\frac{1}{4}$ in. long; it enters the hole in the headstock which contains the leadscrew dog-clutch. The boss is attached to the headstock by an M5 countersunk Allen screw which goes into an existing tapped hole. The boss has an axial hole reamed $\frac{1}{16}$ in. which serves as a bearing for the gear spindle. This spindle has a tongue milled on its inner end as shown, which engages with the sliding portion of the leadscrew dog-clutch. The outer end has a flanged collar on which the

changewheel is mounted; this collar is pinned to the spindle in a position to allow a thou. or two of end-float in the bearing. The flange of the collar carries a pin of $\frac{1}{16}$ in. steel which enters a hole in the changewheel to prevent rotation. These details are clear in the photographs.

The toothed pulleys are supplied with a bore of $\frac{1}{4}$ in. which needs to be opened out. The one for the mandrel requires a bore of 15.5mm, the other a bore of $\frac{1}{4}$ in. Obviously concentricity must be maintained. The method used was as follows. A bit of scrap steel was chucked and turned down to $\frac{1}{4}$ in. Each pulley was mounted on this, secured with its own grub screw and the flanges turned down enough to get them true and parallel with the bore. Each pulley was then gripped in the four-jaw chuck by the flanges and the bore set to run true with a dial indicator. The holes can then be opened out with a boring tool in the usual way. The boss of the mandrel pulley was turned down to $\frac{1}{16}$ in. dia. for the mandrel handle, to be described later; the boss of the other one removed completely. New grub screw



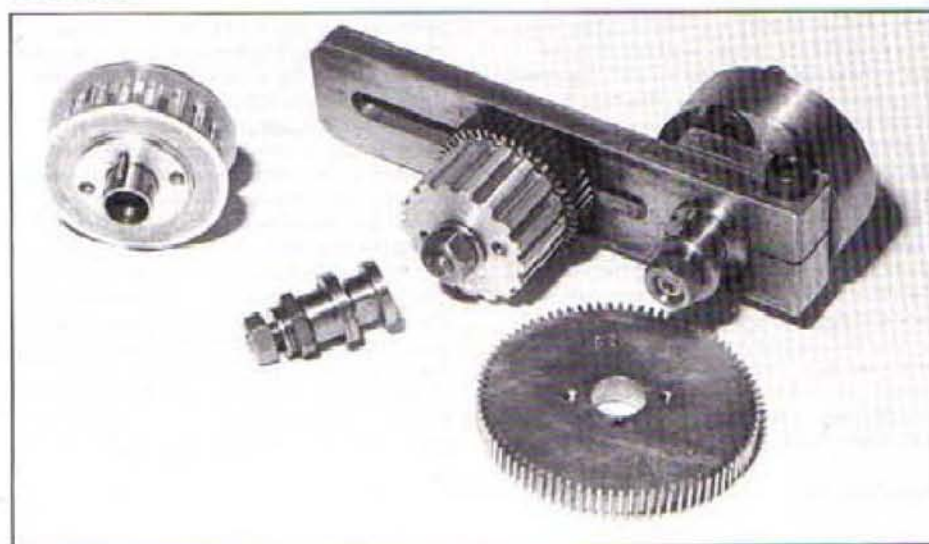
holes were drilled and tapped in the faces of the pulleys.

As mentioned previously the 17-tooth pulley was not a stock item so had to be made. The Chronos DD 62 division plate does not include 17 and it did not seem worth buying another one for this one-off job, so I used an old method I had seen described many years ago but have never had occasion to use before. A line of holes was drilled along the centre of a strip of flexible brass 1/4 in. wide using a simple drilling jig as shown in **Photo 5** which also shows the finished disc. The actual distance between the holes is not important so long as they are equally spaced and in a straight line; the jig will ensure this. The number of holes required is one more than the number of divisions, 18 in this case. The distance between the first and last hole was measured and this figure divided by 3.14 to get the diameter of the disc required. A suitable disc of 12mm plywood was mounted on a stub mandrel in the chuck and turned down carefully until the end holes in the brass strip coincided exactly when the strip was wrapped round the disc. The strip was then fixed to the disc with a few wood screws. The resulting division plate should be accurate enough for most purposes if the operations have been carried out with reasonable care.

The pulley was cut using the same set-up as previously described for cutting the changewheels. An aluminium blank was turned to a diameter of 1.06 in., calculated



Above: Screwcutting bracket and gears - rear view. Below: Another view of the components.



**TABLE 1
INCH THREADS**

Driven pulley 17 teeth T.P.I.	Gear 1	Gear 2
16	60	40
18	80	60
20	72	60
24	48	48
26	36	39
28	36	42
30	64	80
32	60	80
36	48	72
40	48	80
48	40	80
60	32	80

**TABLE 2
METRIC THREADS**

Pulleys 18 teeth Pitch mm	Gear 1	Gear 2
0.4	32	80
0.45	36	80
0.5	40	80
0.6	48	80
0.7	42	60
0.75	48	64
0.8	64	80
0.9	72	80
1.0	48	48
1.25	80	64
1.5	72	48
2.0	72	36

Division plate and drilling jig for 17 tooth pulley.



by multiplying the diameter of the 18 tooth wheel by $\frac{1}{16}$. A fly-cutter was made from silver-steel to fit the tooth spaces. The Chronos division plate was removed from the mandrel plug and the improvised one substituted; the detent temporarily mounted on a piece of angle to enable it to register in the holes. The tooth depth measured at about 0.040in. After cutting the teeth the belt was checked for fit; it seemed a bit tight so a few thou. were taken off the diameter until the belt fitted without stretching. It remained only to take the sharp corners off the teeth with a fine file.

Both the driven pulleys were fitted with brass sleeves $\frac{1}{16}$ in. external diameter with $\frac{1}{16}$ in. bores, projecting $\frac{1}{2}$ in. from one side of the pulley, which act as bearings and as mountings for the changewheels. These sleeves were fixed in with Loctite 601. Each

pulley has also a pin $\frac{1}{16}$ in. dia. which enters a hole in the changewheel to prevent relative rotation. These details can be seen in Photos 3 & 4 which also show the studs on the bracket. The centre stud is only required for cutting left hand threads, to hold an idler wheel for reversing the leadscrew rotation.

The Toyo lathe is not provided with a split nut, so that when screwcutting, the saddle must be returned after each cut by reversing the motor. It is important not to disengage the leadscrew clutch until the thread is completed, otherwise it will be necessary to use the low-speed countershaft previously described; however, for short threads close to a shoulder it is safer to turn the lathe by hand using the handle described, which fits onto the boss of the 18-tooth pulley on the mandrel.

List of suppliers

Note - the author has no connection with any firm mentioned here.
Bond's o'Euston Rd. Ltd. Arundel House, Rumbold Hill, Midhurst, Sussex GU29 9NE.
 Worm gears.
Chronos Ltd., 95 Victoria St., St. Albans, Herts.
 Division plates, free-cutting silver steel.
Davall Stock Gears Ltd., Welham Green, Herts AL9 7JB.
 Toothed pulleys and belt.
G.L.R. Distributors Ltd., Hartham Lane, Hertford, Herts SG14 1QN.
 Metals, Tufnol, belting.
Shesto. Unit 2, Sapcote Ind. Estate, 374 High Rd., Willesden, London NW10 2DH.
 Plastic belting.
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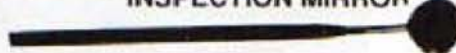


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MILLING

PART 1

FOR BEGINNERS

In this, the first of three articles on milling for beginners, the areas of the machine and work holding are considered

Those who have been involved in home metal working activities for, say, more than 15 years, will remember the times when owning a milling machine was only for the few.

The reason for this was two-fold. Firstly, and probably the major reason, was one of cost, there being no manufacturer with a product aimed at the home enthusiast, and very few small machines for the industrial users either. In view of this any second-hand machines, even if affordable, would probably have been far too large.

This situation began to change rapidly some fifteen years ago, particularly with the arrival of the now popular drill/mill from far eastern manufacturers.

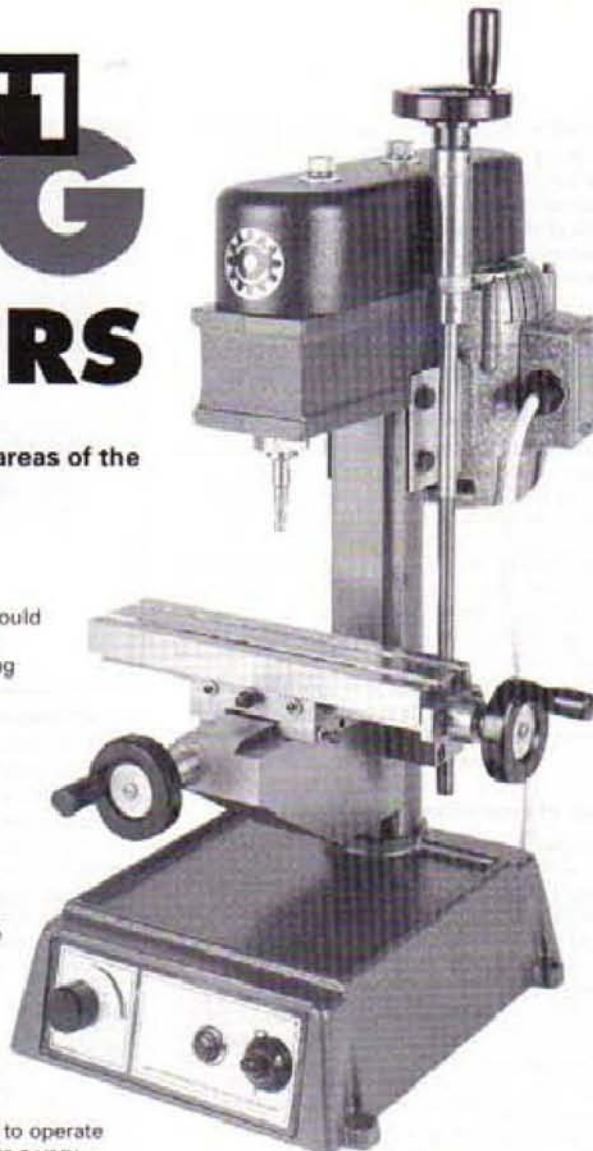
With this situation the milling machine can be considered a newcomer, and whilst far more are now owned, the MEW survey showed this still to be only around 50%. From this it can be deduced that there are many who have recently purchased a machine for whom milling is largely a new activity. Also there must be those who also anticipate the purchase of a machine within the next year or two. It is for the benefit of these people that this article is written, but the experienced should continue to read on, as hopefully there is something here for everyone.

Types of machine

Newcomers to the hobby could be excused for believing that there is only one type of milling machine, being the vertical milling machine. That is not so, though it is reasonable to consider that in view of its predominance, it is the correct type for our applications.

Milling machines fall into two categories, Vertical and Horizontal, this indicating the orientation of the machine spindle, and being the main but not the only difference.

Each type has its own main way of working, but can also take on the methods of the other to a limited extent. The horizontal machine is intended primarily to operate with a circular cutter, rather like a very robust circular saw. This is fitted onto a mandrel which is supported on bearings either side of the cutter. The vertical machine has a cutter (endmill) not that much different in appearance to a twist drill, which projects out from the bearing



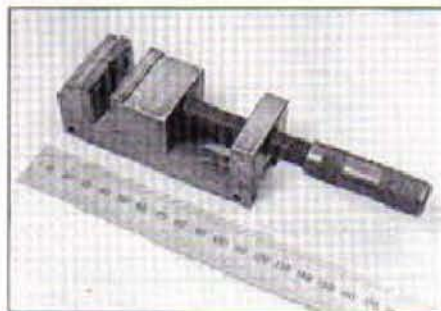
A lightweight vertical milling machine; this is the Cowells machine from Small Machine Tools Ltd.

arrangement. The mandrel, together with its outrigger bearing on the horizontal machine, can be removed, and an endmill fitted to the machine, albeit in the horizontal plain. Similarly, small circular cutters can be fitted to the vertical machine, but in this case without the benefit of the additional bearing to support it.

The other difference is that, for the horizontal machine, the cutter is maintained in a fixed position, and the three axes are all achieved by moving the table. For the vertical miller the third axis (at least in the case of the mill/drill) is almost always achieved by moving the cutter up and down, rather like a drilling machine. This creates the possibility of becoming dual purpose, as both a drilling machine and a milling machine.

A third type of machine is the universal milling machine; this has both a horizontal spindle and a vertical spindle on the same machine, and a table which can be swivelled in relation to the cutter. Except for the few who have space and money available to purchase two machines, this is the ideal method of having both methods of milling available.

Unfortunately this type of machine is not made by many suppliers, and probably the only one suitable for the majority of home machinists is the Sharp MkII made in this country by Town Bent Engineering Co. (Henry Street, Rishton, Lancashire BB1 4JJ. Tel: 0254 876644).



A good vice for small parts; tapped holes in the bottom enable it to be screwed to a base if required.



Tilting vice, typical of those supplied with many drill/mills.



This drilling vice would be unsuited for use on the milling machine.



Underneath the drilling vice; construction is not man enough for milling.

This is, as one would expect, a little more expensive than a normal mill/drill, and for those who cannot justify the extra expense, a vertical mill is best suited to most of the likely work.

An interesting aspect of the horizontal machine is that if a faceplate or chuck is fitted to the machine spindle, turning work can be undertaken. The considerable advantage of this is that it is likely to be able to cope with much larger diameters than in the lathe available.

The machine spindle will not accept a chuck or faceplate direct, and this will have to be mounted onto an adapted taper. Except for gear cutting and slitting where both operations require disc cutters, the vertical machine is either equal to, or preferable to, the horizontal machine. Even here, with care and accepting its limitations, both operations can be carried out, as will be discussed in subsequent parts of this series.

Except for the occasional comparison this article will now deal with the vertical milling machine only, as this is by far the most likely to be owned.

Size of machine

Unlike the lathe, where the statement of centre height and distance between centres gives a quite good indication of a machine's capacity, the milling machine's capacity is much more difficult to visualise.

Unless the machine is intended for entirely very delicate work, it is true to say that the largest that can be afforded and for which space is also available, is preferable.

The parameters that are of importance are:

- Size of Table
- Traverse in the X and Y axes
- Traverse of cutter spindle
- Max distance between table and cutter spindle

Of these, table size is the most important as the remainder will be largely dependent upon this. Unfortunately these do not give the inexperienced much indication of the machine's capabilities. This is because so much of the table is frequently taken up with the associated equipment for work holding, rather than the item being machined.

In view of this situation it is difficult to be precise in endeavouring to advise a reader on this matter. As a general rule, a table size of 20 inches x 5 inches would be a good size to aim for, but if finance or space does not permit this, do not be put off buying a smaller machine. Much fine and interesting work has been, and is still being, carried out on a small lathe cross slide.

Speed range

Unless the machine is to be used entirely for light duty work, a low speed of 100 RPM would be desirable, though for many machines bottom speed is likely to be higher than this. Top speed is less of a problem, but around 2000 RPM is worth aiming for.

Using the machine

It is now time to consider putting the machine to work and to do this the correct ancillary equipment is essential. As supplied, the machines always require additional items, these to be made or purchased.



Home constructed Tee nuts, studs and washers; the screws are proprietary high tensile grade 8.8 and the hex nuts grade 8.

It is surprising that, even those machines which come with chuck, vice and cutters, sometimes do not come with the required tee nuts, studs, nuts and washers, to enable the vice to be fixed to the machine table. The requirements for these will be covered in detail, but first one other essential factor is to be commented on, being that of safety.

Safety

It is essential to realise that the milling machine has great potential for danger, without doubt being more dangerous than the lathe. For this reason short cuts to work holding or over ambitious heavy cuts are taboo. It is quite possible to snap off a cutter at the shank if the work moves during machining. Damage to the workpiece, and worse, serious injury to the operator can result.

Fully guarded machines are not practical in this environment, but a simple transparent guard on a flexible arm will be useful when machining materials which throw a large amount of fine swarf.

Ancillary equipment

A range of ancillary equipment is required to complement the machine, and certain minimum standards must be met to ensure satisfactory results. Typically, a vice which is considered acceptable on a drilling machine may be far from adequate on the milling machine.

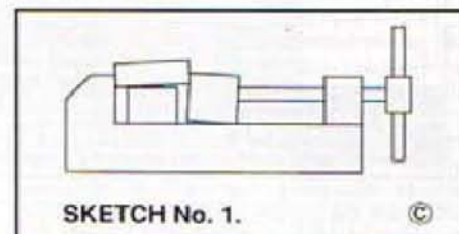
The vice

Money spent on a good vice will be well spent; there are many different types of vice but these can largely be grouped into two categories. These are the ridged type which clamps firmly to the machine table and the tilting vice, frequently supplied as standard with the far eastern Drill Mills. There is, of course, a wide quality range in each type.

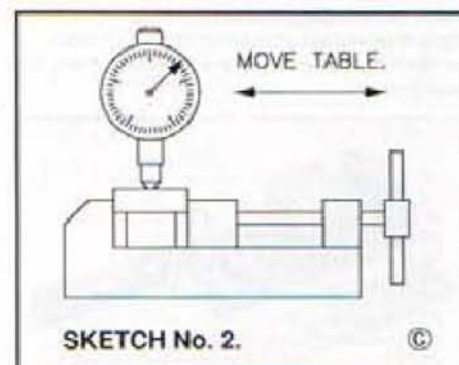
The first requirement of the vice will be strength. A good robust construction is essential. This can largely be judged as OK, or not, by just looking at the item. The second requirement is one of accuracy. A well-made vice will probably be accurate but can only be definitely established as such by a few simple tests.

The third and most likely cause of

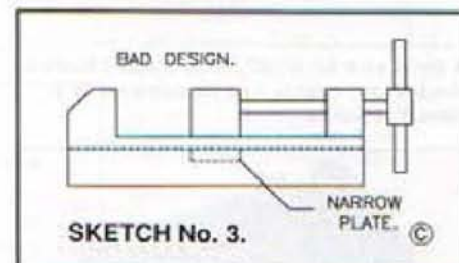
problems will be jaw lift, as even a very little is unacceptable. It will be difficult to be sure how much exists without carrying out tests, though observation of the construction will give some indication. A very narrow moveable jaw with only a narrow keep plate will certainly give cause for concern.



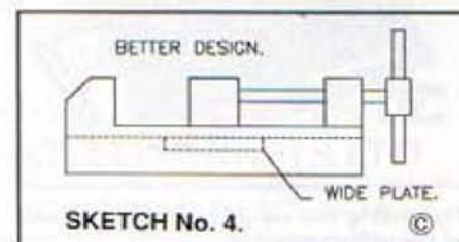
SKETCH No. 1.



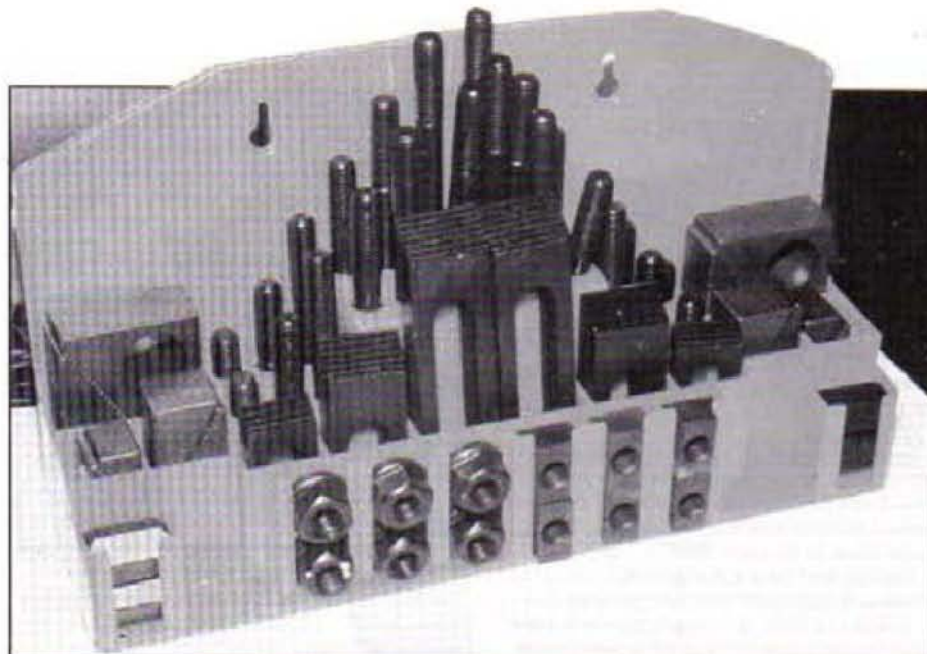
SKETCH No. 2.



SKETCH No. 3.



SKETCH No. 4.

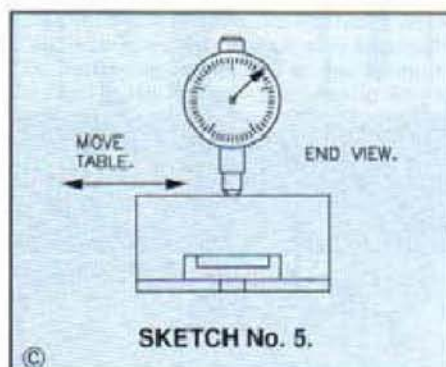


A proprietary clamp kit, typical of those available from many suppliers; this one is from Excel Machine Tools of Coventry.

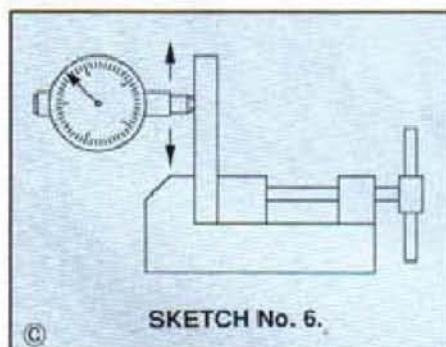
This condition is shown exaggerated in **Sketch 1**, whilst a method of testing for same is shown in **Sketch 2**; examples of both good and bad vice design are shown in **Sketches 3 and 4**. These sketches presuppose that only a vice at the cheaper end of the range is being considered.

Vices with much longer jaws, and as a result obviously much less likelihood of jaw lift, are available. These though cost around £100 or even more and, as a result, are quite disproportionate to the cost of the cheaper milling machines.

It is also necessary to know that the vice will accurately hold work, when the work is supported by the various vice surfaces.

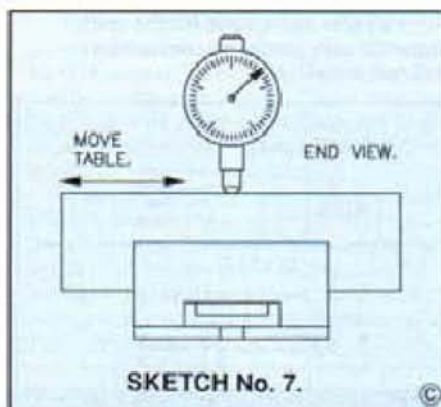


SKETCH No. 5.

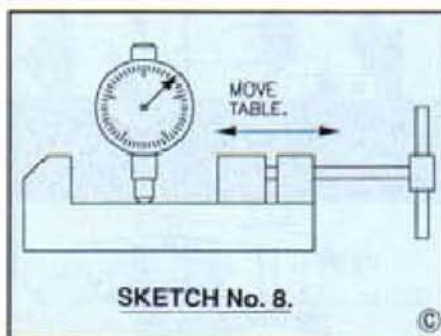


SKETCH No. 6.

Sketch 5 shows the test to see if the top of the fixed jaw is parallel to the table surface, essential as certainly work will sometimes be located from this. **Sketch 6** is the test to find out if the jaw is at right angles to the table surface. If a tilting vice is being tested it must be seen to be fully at its lowest position.



SKETCH No. 7.

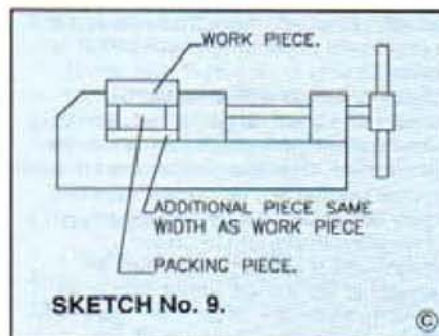


SKETCH No. 8.

Finally, the accuracy of the bed of the vice must be ascertained to see that it is parallel to the machine table in both directions. These tests can be seen in **Sketches 7 and 8**.

Inaccuracies in a vice can be overcome rather than eliminated; for example, if the test as in sketch 5 shows an error a shim can be placed under the work at one end to compensate for this. This approach should not be considered as a long-term solution; the vice should either be corrected or a better one obtained.

If the vice is one of the cheaper variety and is found inaccurate in some way, it would be a good early exercise to dismantle it and re-machine the required surfaces to achieve a satisfactory result. At the same time the keep plate could be lengthened to minimise the problem of lift. (This will be the subject of an article in a later issue. Swivelling vices present some critical considerations when machining. Ed.)



SKETCH No. 9.

As jaw lift is difficult to avoid completely, whenever work is to be held only at the top of the jaw, efforts should be made to minimise it. The method shown in **Sketch 9** of placing an additional piece of material of equal width to the work piece, at the lower part of the jaw, will greatly improve the situation. Also very important, this will avoid undue strain on the vice itself.

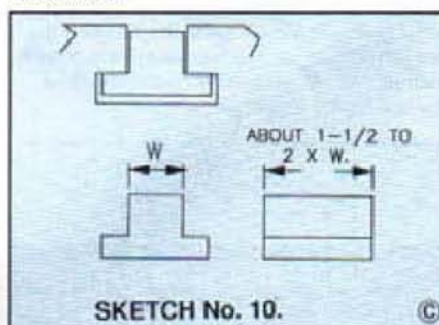
Tee nuts

Having discussed the vice, some means of fixing this to the machine table is required. It is surprising that machines are frequently not supplied with this essential item of equipment. These would not be difficult to make, and would be a useful first exercise for the machine. Complete sets of clamping components are available for purchase, for those who prefer to take this route.

Do not rely on using the heads of an ordinary hex headed bolt to go into the tee slot. Even if it is a larger diameter thread, it is unlikely that the head will have sufficient size to spread the load adequately. This will lead to possible damage to the tee slot itself, and also will not guarantee adequate clamping of the device being held.

If it is decided to make the tee nuts, a temporary arrangement will be necessary to hold the vice first time round. Without doubt the best approach is to make two, using a saw and file generally as about to be detailed.

The most important factors with regard to tee nuts are the depth of thread available, and the length being adequate to spread the load applied to the tee shot itself. The nut should be a reasonable fit in the slot, but not so close that small particles of swarf prevent the nut being slid into place with relative ease. Adequate clearance below the nut is essential for this is where most problems from swarf will result. Of course the slot should be reasonably well cleaned before a tee nut is introduced.



SKETCH No. 10.

The depth of the narrower portion of the nut should be almost as great as the corresponding part of the slot to ensure maximum depth of thread is available. These requirements can be seen in **Sketch 10**. It remains to decide on the thread

diameter; probably more than one size will be preferable depending on a number of factors.

Sizes of M12 and M10 would be considered a good range for the average machine and M10 and M8 for the smaller size machine. Only use smaller than this for the very small machines; these sizes will largely be governed by the slot itself.

Providing the length of thread engagement is at least 1 1/2 times the diameter of the thread, bright mild steel should be adequate. When they have been made they can be oil blued to give a traditional finish.

Studs and nuts

The studs present more of a problem. Ideally they should be high tensile and unless long high tensile screws can be obtained and the heads removed, studs will have to be made or purchased.

Providing thread sizes have been chosen at the larger end of the range, then bright mild steel studs will suffice with care. To purchase these though is, without doubt, best unless suitable steel is purchased and the studs made from this.

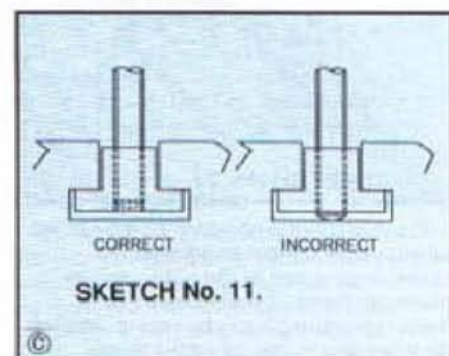
Suitable 8.8 high tensile studs can be obtained in a wide range of sizes from Rotagrip, 16-20 Lodge Rd., Hockley, Birmingham B18 5PN (Tel: 021 551 1566), also Town Bent mentioned earlier. If normal size nuts are to be used with the studs it is essential that these are grade 8. As an alternative, thicker nuts can be made from normal bright mild steel, but these should have a minimum length of twice the thread diameter.

One further item to complement the tee nuts and studs are the washers and these are also often neglected. Washers intended for more normal applications will be, without doubt, far too thin and in many instances too small a diameter.

Clamping will frequently be onto a slot rather than a round hole – or even if a round hole, this may be much larger than the stud.

Under these conditions a substantial washer is as important as the other items, if not more important. An outside diameter of about three times the thread diameter and about 1/8 inch to 1/2 inch thick would be about right.

Finally, it is essential to make sure the stud enters the tee nut to almost its full depth to achieve maximum strength, but for it not to pass through and contact the table. If it does, the resulting jacking action, if it turns a little whilst being tightened, will make damage to the tee slot flanges highly likely. These requirements can be seen in **Sketch 11**. Studs as purchased will have a plain portion to avoid this possibility and this is a highly desirable feature.



Clamps

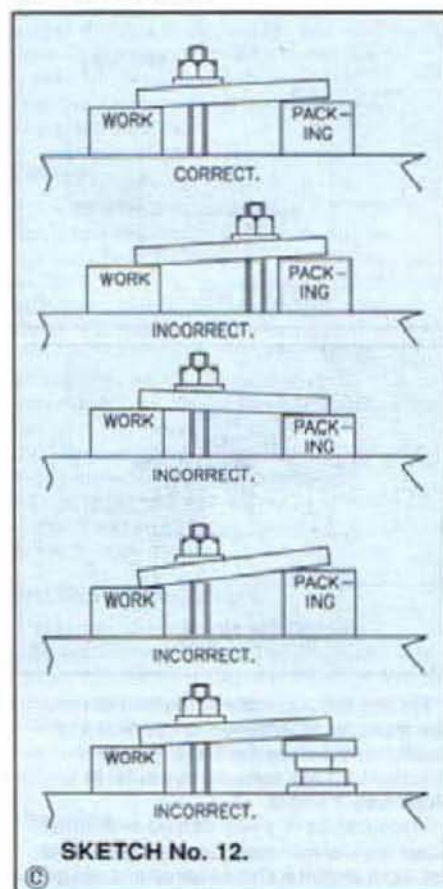
In the case of a vice and other similarly fixed items, a slot or hole will be provided to enable the item to be clamped to the table using just the tee nut, stud and associated parts.

Many items though will have no provision for clamping them to the table and some additional clamp bars will be required with packing to complete the task. This is not an area to make do with makeshift arrangements, for if the work is not properly fixed, the potential for disaster is very real.

Number one requirement is strength; do not attempt to get by with relatively flimsy bars. Even having obtained robust clamps there is still the method of applying them to the work to be considered.

Clamps can take a number of forms, the simplest a plate with just one hole for the stud. Alternatively, a longer strip with a slot – this makes it easier to get the work, stud and packing in the best relative positions.

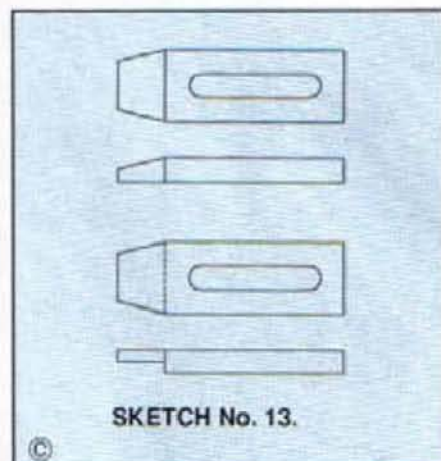
The plate would probably be 1 1/2 to 2 inches square and around 3/8 inch thick and with a single central hole for the stud. These are very useful for clamping in confined locations.



The most generally useful strip with slot would be made from 1/2 inch thick, the width being about three times the width of the slot. These dimensions are rough guidelines only and will depend very much on the length of the bar and the likely span it is to cover. Thinner material, say 3/8 inch thick, would certainly be suitable for the shorter bars around 2 inches long.

Having acquired the correct clamp bars it is still essential to apply them correctly. Basic rules are as follows and can be seen illustrated in **Sketch 12**.

The clamp stud should be as close to the work as is possible, and in any case closer



to the work than to the packing. The packing should be higher than the work but only just. Finally, the packing should be stable, not being made up of many irregular bits and pieces.

Small variations can be made to the clamp to make it more universally acceptable; the end to be placed on the work can be tapered so as visibility of, and access to, the workpiece are improved. This can be seen in **Sketch 13**.

Clamp bar packing

Numerous ways of providing packing for the non-workpiece end of the clamp are available. Probably the best, but not without its limitations, is the jack screw, as can be seen in **Sketch 14**. It has the advantage of being continuously adjustable over its range, and is therefore easy to arrive at the best height.

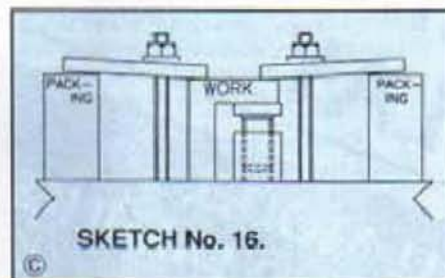
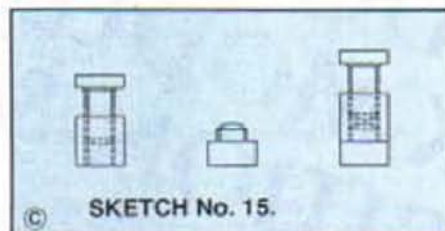
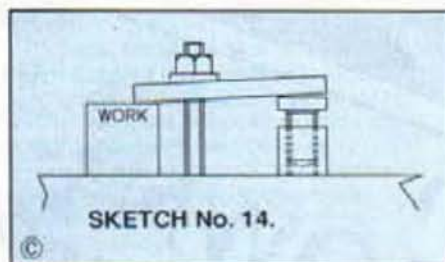
The limitation of the screw jack is that it is not possible to cope with heights of below about 1/8 inch, and will then only be adjustable over a small range so that quite a number will be required to cover the smaller dimensions. The number of jacks



The recent Model Engineer Exhibition offered the chance to examine and compare machines; this imported model was part of the Drapers Tools Ltd display.

required can be minimised by the application of fixed height packing pieces, as can be seen in **Sketch 15**.

Another advantage of the screw jack is its ability to be used to support irregular shaped items on the machine table. This



will enable the part to be firmly clamped, as can be seen in **Sketch 16**.

An alternative packing arrangement is provided by two interlocking stepped blocks. These permit the height to be altered by set increments, by interlocking them in differing positions. The steps are slightly saw toothed in shape to ensure they interlock securely.

The final and obvious method is to use a block of metal of appropriate height. This being rather inflexible the temptation will be to use a piece not the ideal height. Alternatively, the height can be increased by the use of more than one piece, which is acceptable only providing the resultant stack is stable. See **Sketch 12**.

The angle plate

To complete the basic kit of parts for work holding there is the fixed ninety degree angle plate. The other items strength is all important and a robust angle plate around 6 x 5 x 5 inches would be a good size to consider for the average size mill.

If a top of the range angle plate is purchased accuracy should be assured, but similar tests to some of those for the vice will be worth carrying out. Check that the face and ends are at ninety degrees to the table and also that the top is parallel to the table.

These tests should be repeated using the second face as the base. If errors are found then it may be necessary to machine the angle to eliminate them. In this case perhaps it would have been better to start from a raw casting such as those supplied by College Engineering Supply, 2 Sandy

Lane, Godsal, Wolverhampton, WV8 1EJ (Tel: 09074 2284).

Having said that, a word of warning here is essential. Accurately machining an angle plate without a second precision angle plate being available is very difficult and not a task for the beginner.

Other accessories

The above lists the basic requirements for work holding and their essential requirements of robustness and, highly desirable, accuracy. Other items of equipment will be found very beneficial such as vee blocks, adjustable angle plate, rotary table, etc.

Obtaining these should be left until experience has been fully gained with the basic items although some will consider that the vee blocks and adjustable angle plate should be considered basic items of equipment also. This is probably true and these should be obtained as soon as finances permit, with the original machine if possible.

The rotary table is, though, without doubt, a specialist piece of equipment which should only be purchased if a definite use for it can be seen.

Part two

In the next part of this series, milling cutters and the method of holding these will be covered - a much more complex problem than is likely to be envisaged. The series will be concluded in part three, when actual milling operations will be considered.

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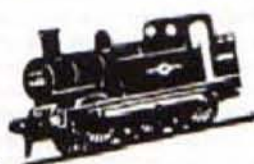


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KEEPING RUST AT BAY II

The large number of letters regarding the article on rust prevention indicates this is a subject that many of you are very concerned about. For this reason, this page of letters has been included, which hopefully will further help to minimise this problem for a large number of readers.

Of course, not all readers suffer this problem; quite a few Australian readers have commented that their need is not to install heating, but rather air conditioning! I would warn you though before you send for your emigration papers, that readers from that part of the world frequently comment on the difficulty of obtaining tools and materials ... Ed.

Having spent a lifetime in cotton spinning where humidities are vital to processing and to commercial activities, I felt I had some understanding of the problems which faced me, working in a 20 x 10 ft. garage of asbestos sheet construction where the insulation values were almost nil.

Whilst building a 14ft. sailing dinghy I found that my tools very quickly went rusty. Realising that a change of building was very unlikely some experiments were done.

It was found that providing articles were kept in drawers, they would not rust even if not oiled, e.g. HSS wood turning tools, so now all articles which can be are placed in a drawer.

This did not help with the Super 7, vertical mill, pillar drill, etc. These are now covered at all times with lots of cloth, old sheets, etc. Over some years this has protected against the problem of cold machinery in the atmosphere, where the relative humidity will cause dew point conditions on the machine.

The situation where machines are cold and the surrounding air is warm and humid, e.g. when a cold spell is followed by warmer westerly rainy weather, is the danger time.

For the technically inclined, relative humidity may be defined as the ratio of the pressure of aqueous vapour actually present at the existing temperature, to the pressure of vapour which would be present if the vapour were saturated at the same temperature.

As the masses and vapour pressures have nearly the same ratio it is often sufficiently accurate to use the masses of aqueous vapour present.

To measure relative humidity the wet and dry bulb is a very poor method and has long been superseded in industry.

The basic method of testing is to use Regnault's hygrometer. This consists of two test tubes each with a thimble of silver at the bottom; ether is placed in one and also a thermometer, air is drawn through and cools, by evaporation, the thimble.

The dew point temperature is recorded both ways up and down, to give better accuracy and the other thimble is used to give a comparison with and without moisture.

Tables are used to obtain the relative humidity.

Mr A. Lord, Bolton

At this time of year in the South West

SCRIBE A LINE EXTRA

fan but this is rather an expensive method. A friend has put in a de-humidifier and is collecting quantities of distilled water.

Can your readers suggest better methods as I believe I am raising the dew point and the de-humidifier extracts moisture from the shop atmosphere which is constantly being changed for moist air.

Is there any low cost method of drawing air from outside to maintain a positive pressure in the shop of dry and warm air?

**Michael Dover
Truro**

I was interested in the article in the Dec/Jan copy of M.E.W. since I have a small workshop utilising one end of a domestic garage. The garage, which measures 17 ft. x 9 ft. internally, is attached on one side to the house and is constructed otherwise of a single skin of brickwork with a flat timber and felt roof. The door is a standard 'up and over' aluminium door. No effort has been made to render the structure draught proof and daylight can be seen between the door jams and the brickwork and around the door itself. The car (restricted to no longer than 13 ft.) goes in wet or dry depending on the weather during its last trip of the day. Some work can be carried out with the car inside and the door shut.

The workshop gear consists of a Myford ML10, a Hobbymat mill/drill and a cheap and nasty small bench drill together with the usual assortment of hand tools. Having bought the ML10 from new I was soon faced with saving my investment from the ravages of rust due to condensation which was severe. Incidentally I discovered that condensation was worse if the equipment was covered.

My solution to the problem was to keep the body of the lathe permanently above the temperature of the ambient air. This was done by the simple expedient of placing a tubular heater (2 ft. long/60W/ft.) in close proximity to the rear of the lathe bed which keeps the machine warm to the touch. My experience is that the heater is unnecessary between April and September and could probably be thermostatically controlled with advantage if an annual cost of about £37 is considered excessive. All the bright metal in the workshop has remained reasonably so in six years of use and the slight circulation of warmer, drier air in the vicinity of the bench keeps other items in good condition.

I can recommend this method as being reasonably cheap, simple and effective where the cost of maintaining an ambient temperature, even as low as 45°F, would be

prohibitive.

G. Brice, Cardiff

I have a brick-built workshop 20 ft. x 10 ft. My garden is a short steep valley and the one end of the workshop is below ground with my garage on top of it. Ideal conditions for heavy condensation. The humidity meter often swings from 40 to 85.

Nearly three years ago I bought a new Naerok 6 in. x 36 in. geared head lathe. I spent some time considering whether to use suds or oil in the coolant system and have never regretted deciding to use neat cutting oil. All unpainted parts are still as bright as new. It does not cool quite as much as suds but seems to machine easier. An old toothbrush dipped in it is a great help in hand tapping or on the drill. It could do with a larger tank as after prolonged machining, oil is retained on the swarf but will drain back when not in use.

It is true that when machines are very old, like my 12 in. shaper, they seem to stabilise with a light brown surface.

I do use a fan heater on 'Economy Seven' for an hour or so each night. I get very heavy condensation on upended steel bar offcuts in an open wood box on the concrete floor but then you would machine that off anyway.

Stan Reavenhall, Bromsgrove

The recent article on 'Keeping Rust at Bay' was most interesting, having had the same sort of problems as the author. As I saw it the problem resolved itself into a simple equation:

$$A(\text{water}) + B(\text{oxygen}) + C(\text{steel}) = \text{RUST}$$

Keeping the steel tools away from the other two by means of oil is fine until you wipe a piece clean and then forget to re-oil it. Smaller items can be placed in tins with V.P.I. paper but this still leaves the major items vulnerable to the brown menace.

The only practical way to tackle the problem is to eliminate or severely reduce "A".

Firstly eliminate rising damp as far as possible. My workshop is a sectional, wooden garden shed which rests on slabs of concrete resting on the clayey soil. A few years ago we emptied it (what a job!) onto the lawn on a warm, dry day; removed the roof and by means of two lifting bars across the inside, two of us lifted the walls clear of the base. The base was inverted, creosoted and replaced onto strips of damp proof course material. Re-assembled and with the roof re-felted the reduction in internal dampness and rusting was remarkable. The exterior walls are sprayed annually with a timber preserver (a half

rusting of tools and steel stock is a very real problem.

I have partially solved this by installing an off-peak storage heater with a booster

hour job!) using the domestic cylinder vac. and a glass and plastic low pressure spray gun (Electrolux circa 1955). The rain runs off the wood like water off a duck's back and the inside walls remain very dry.

Secondly the absolute humidity of the air in the workshop can be reduced by using an electric de-humidifier from early until mid morning; a short burst after use can be helpful too. Philips produce an excellent plug-in electronic digital timer (HR 5075) to control all this.

'Er indoors' will love you for this set-up! Wet washdays will be a thing of the past. Put the washing on clothes maidens in the kitchen, or other small room, add one de-humidifier, close the windows and doors and go to bed. By first light the washing is dry; no streaming windows, just half a gallon of water in the base of the unit fit to put in your car battery or onto the delicate glories in the greenhouse. Transfer the unit to the workshop and, hey presto, no rust!

As a retired Geography lecturer, and frustrated engineer, may I take this opportunity to contradict the cricket commentator's favourite remark about the air being 'damp and heavy allowing the ball to swing'. Damp air is LIGHTER than dry air, volume for volume, so it rises; hence the workshop's closeable vents should be placed high in the gable ends.

Electrical heating, although expensive, is probably best from the dampness point of view, though probably a bit dangerous, with swarf flying about, unless you use a greenhouse type heater. I use a Tilley lamp in the winter, purely for its heat, despite the fact that it generates water vapour – but so

does my breathing – heavy at times! A short period of de-humidifier, after working, seems to have the desired effect. When you're pressed into wallpapering take the d-H with you; after a winter party or family gathering use the d-H, no condensation on the windows and hence less frequent painting! If the garage doors fit well then it will dry out the garage. Remember, it's a lot cheaper to run than an electric fire and stirs the air up, reducing the chances of a pocket of damp air remaining to rust your precious tools.

Keep up the good work on the magazine; I learn something valuable every issue. With every good wish from the swamps of Bramhall.

D P B Renwick, Stockport

The article headed "Keeping Rust at Bay" made me recall an instruction prepared by our American head office and written into the "Standards Book", copies of which were issued to all companies within our group.

It's "Good Workshop Practice" pages included:

"All exposed bright metal machined surfaces to be protected by means of silicone furniture polish, applied via an aerosol spray and burnished by a soft polishing cloth."

The object was twofold: 1) by providing a "dry finish" it avoided piece-part materials being accidentally marked – even ruined – by oil and grease stains while still retaining the anti-friction effect of a lubricant and 2) the silicone component provided a moisture repellent surface which proved effective even though our

workshop was located in the notoriously damp climate of S.E. Lancashire.

W Brian Taylor, Cumbria

We moved home 18 months ago and from an indoor workshop for many years I'm now having to convert a 12 ft. x 6 ft. garden shed to cater for DIY carpentry and model engineering. I've used polystyrene 1" thick sheets under a floor of marine ply on joists resting on the original concrete suitably painted with bitumen and polythene dustsheet. Walls and the ridge roof are also insulated with the 1 in. polystyrene and covered with hardboard. There is electricity to the shed so I've fitted fluorescent lights and an oil-fired Dimplex radiator keeps it warm. Then in, issue 8, I read the excellent articles on wiring and condensation – just in time!

The shed roof is well covered with green mineral felt but the heat from the sun seems to get right into the workshop much more than the garage which has a corrugated asbestos roof. The sun also produces a lot of heat through the windows. Bearing in mind that heat changes cause condensation, as stated in your article, I wonder if I might suggest two additional ideas for workshops like mine which are exposed to full sun throughout most of the day.

1. Add shutters to the windows to flap down or raised as shades only when the workshop is in use. They would improve security; and privacy during winter evenings when the lights are on.

2. Grow one or two conifers to shade the workshop from the heat of the sun.

F W Morris Thomson, Ruislip

A TAPPING FIXTURE

This tapping fixture, built onto a Black and Decker vertical drill stand, has been provided by Mr P D McQueen of Edgbaston

Most model engineers will at some time have experienced difficulties in keeping a tap straight when tapping by hand. If you own a Black & Decker vertical drill stand then this problem may be overcome by converting the drill stand into an accurate and easy-to-use tapping fixture. The drill stand can be quickly and easily converted back to its original use at any time and, as an added saving, the fixture makes use of the chuck from your portable electric drill. This useful addition to your workshop is quite simple to construct and is made entirely from stock materials, some of which may already be lurking in your scrap box!

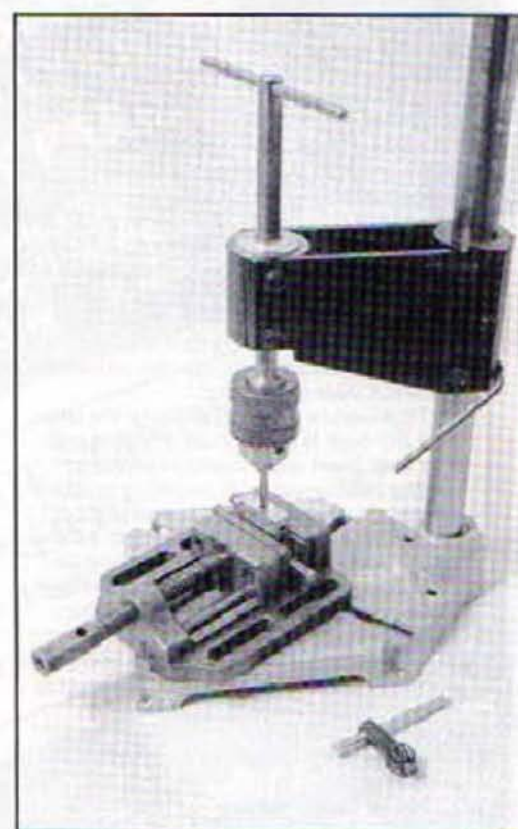
Design

The tapping fixture consists of two guide pieces made from 1½ in. diameter mild

steel bar, one of which slides on the drill stand pillar and can be clamped in any position by means of a single pinch bolt; the other locates the chuck spindle. These guides are fixed together by two side plates such that the chuck spindle is positioned over the centre of the drilling table. The tap is held by a drill chuck which is threaded onto the chuck spindle. The chuck is rotated using a T-handle at the top of the spindle.

Construction

Construction is quite straightforward and should present no problems for a model engineer but one or two practical points are worth mentioning. The pillar guide should be a good sliding fit on the pillar to ensure that the pinch bolt clamping system operates effectively. The pillar has a



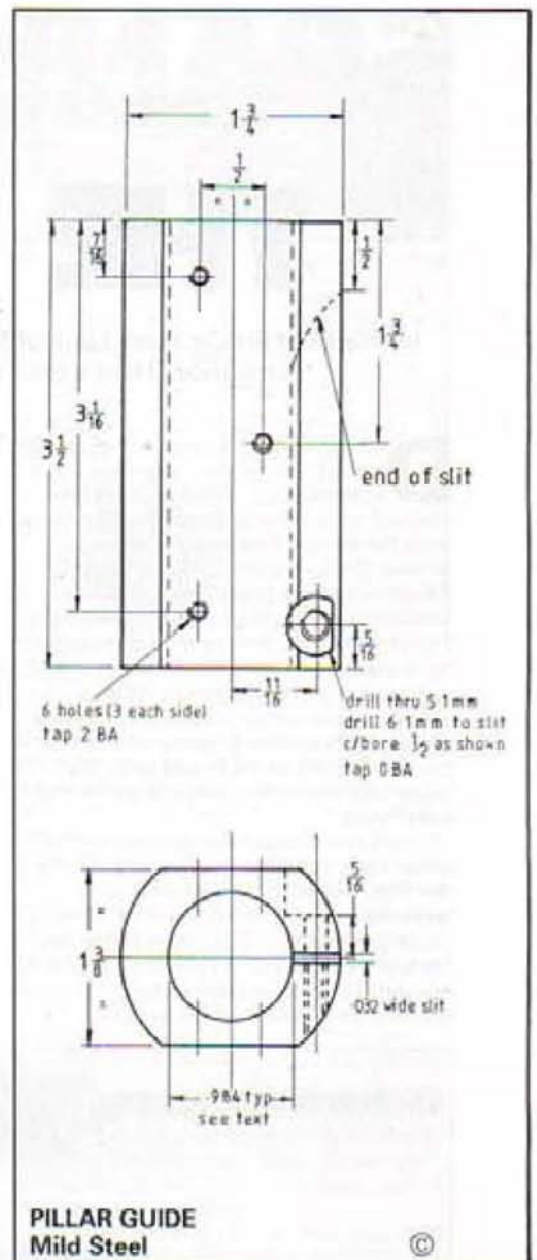
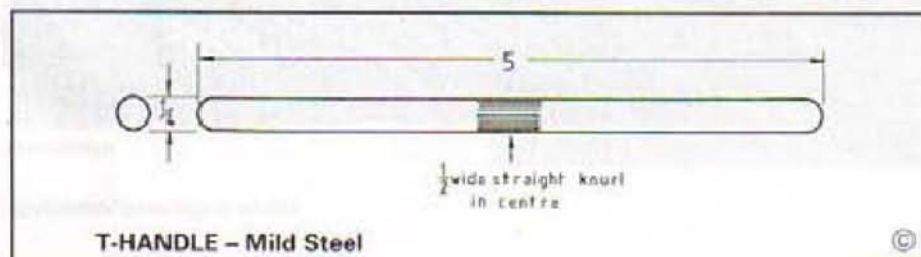
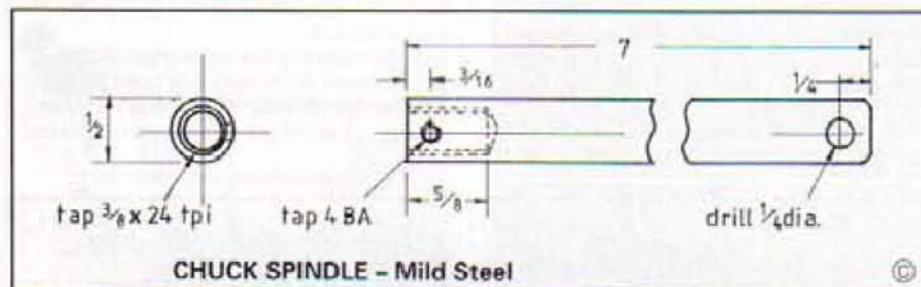
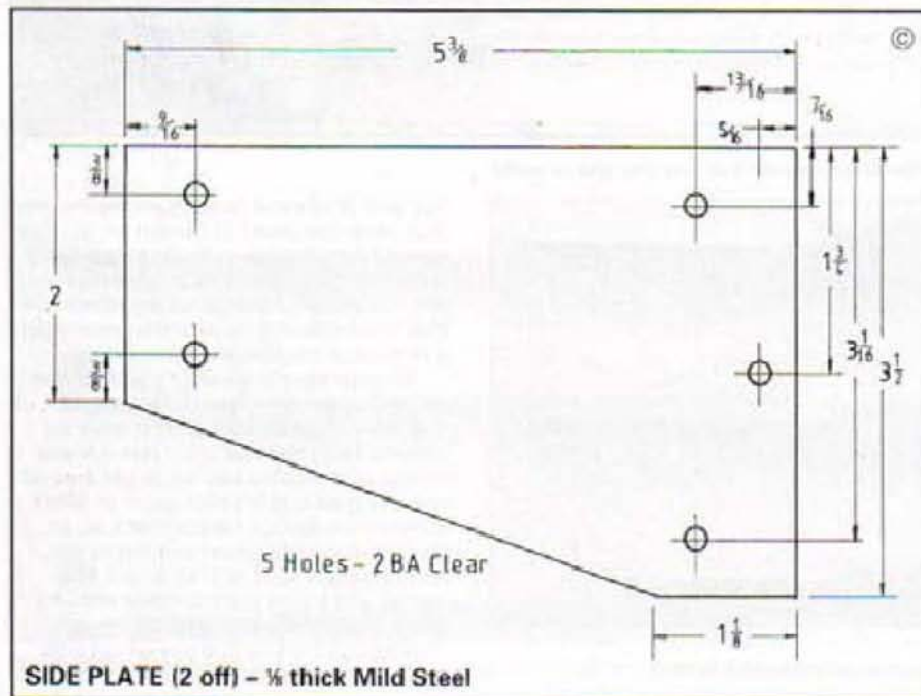
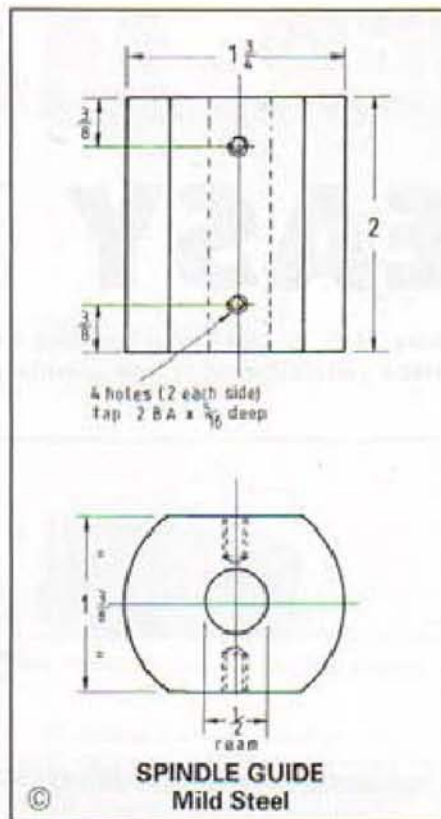
nominal diameter of 25mm (0.984 in.) but this should be checked as the actual dimension may be different by a few thou. The pillar guide has to be bored out in the lathe and, as it is 3½ in. long, this will

require a sturdy boring bar with sufficient reach. The chuck spindle must also be a good sliding fit in the spindle guide. It is recommended, therefore, that the spindle be made from precision ground steel bar and that the guide bore be reamed. The drilling and boring of the guide pieces should be undertaken before milling so that they can be held in a three-jaw chuck.

The pillar guide has a slit machined along most of its length; the width of this slit is shown as 0.032 in. but this is not critical provided that it is sufficient to allow the guide to be pinched securely onto the pillar.

$\frac{1}{16}$ in. thick steel plate is recommended for the side plates but any material providing sufficient stiffness may be used (the author made use of two scrap pieces of $\frac{1}{16}$ in. aluminium, and this is what is shown in the photograph).

The chuck spindle is drilled and tapped to accept the chuck from a portable electric drill. This will normally be $\frac{3}{16}$ in. x 24 t.p.i. A set screw (4BA) is required to stop the chuck unscrewing when a tap is being withdrawn. It is recommended that a recess for the set screw be drilled into the chuck thread; this will prevent damage to the thread which could cause the chuck to bind when being unscrewed. The T-handle is knurled in the middle in order to retain it securely on the spindle.



Assembly

10 2BA hexagon-head screws are required to secure the side plates to the guide pieces. Make sure that the screws for the pillar guide are not so long that they foul on the pillar. An OBA socket-head cap screw, with washer, is used for the pinch bolt. Before finally tightening the side plates check that the spindle is vertical with respect to the drilling table. Once assembled all external surfaces should be given a coat of paint.

In use

Work may be held or clamped directly on the drilling table for tapping but small jobs can be conveniently gripped in a hand vice as shown in the photograph. It is important that the tap is secured tightly in the chuck since it is possible to produce quite a lot of torque with the T-handle. For very small threads (10BA and smaller) the feel of the tap tends to be lost and for this type of work the use of a tap in a hand-held pin chuck is recommended. Remember that, for all tapping jobs, a better finish will result if a suitable cutting lubricant (such as Rocol RTD compound) is used.

SPANNER-MAKING

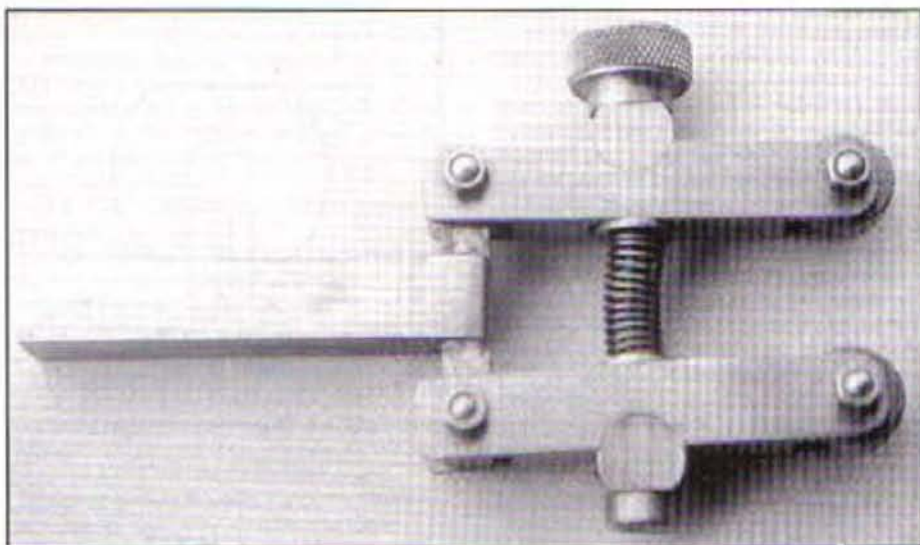
THE EASY WAY

In this brief article Terry Lane of Rockley, N. S. W., Australia we have a nice little project with a very useful conclusion. Here's how to make yourself a set of box spanners as an evening's exercise.

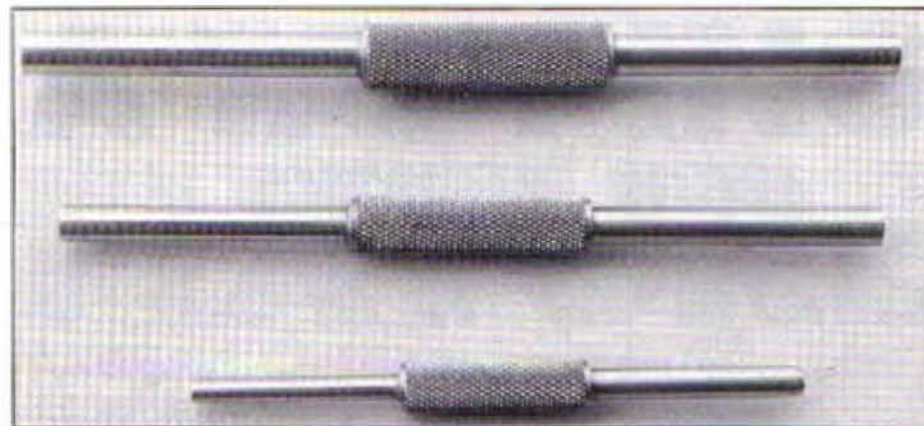
During the early days of my modelling 'career', more years ago than I care to think about, a fellow modeller showed me a set of spanners he had made from the heads of various socket cap screws. Designed, primarily, for use with BA screws, these little spanners were beautifully made and it was not long before I had made a set, albeit somewhat rougher, for myself.

Consisting of nothing more than a shortened cap screw fixed into a hole in a piece of flat material to serve as a handle, they were quick to make and were, for many years the only spanners for BA that I possessed.

The system was expanded somewhat when I was in the final stages of building my *Tich*, the firebox of which was fastened to the boiler by a sort of clamping hinge plate with an inner plate inside the firebox. To fit this item I needed to reach in through a couple of the firetubes to tighten the nuts on the hinge plate studs. To



The Knurling tool that inspired the re-make.



The 'long reach' spanners; the six sizes cover all commonly used BA bolts.

facilitate this an appropriate cap screw was set into a length of 1/4 in. dia. mild steel rod long enough to pass right through the boiler with enough left over to attach a small pair of mole-grips for turning purposes.

Although roughly made for one-off use I soon found myself using this tool for all sorts of jobs where a bit of 'reach' was required and so another tool was made, double ended this time to accommodate 8BA and 6BA screws. This tool body was made from a piece of hexagonal mild steel, which meant that a small spanner could be used to turn it if more than hand tension was required.

It soon became apparent that the hex. body was not needed with the double ended tool, as a hex. Allen key could be

used in the vacant end of the tool to apply tension and so a Mk.III version was made from round stock, this time for 4 and 5BA.

It was easy to overlook the simple. With my tools in almost daily use for many years. I assumed that everybody knew of

this way of spanner making and so the idea was never discussed or passed on. In recent times, however, the spanners have been attracting quite a bit of comment, with a number of people asking about how they are made and the attention prompted a re-think of the system.

The final spur came after a good friend and fellow modeller had done quite a bit of 'leg-work' in getting me a set of knurling wheels. This chap had often commented on my spanners but had never got around to making a set of his own so, in an effort to return the favour, I made him a set of three, two double ended and one single, accommodating 10, 8, 7, 6, 5, and 4BA screws and knurling the handles with my newly complete knurling tool.

Although the knurling turned out a bit funny, it was the first I had done, these tools made my own look like stone clubs and work soon commenced on a second set for myself.

In this country the most commonly encountered BA screws and bolts have a smaller than standard head and the sizes shown in the list are for these small heads.

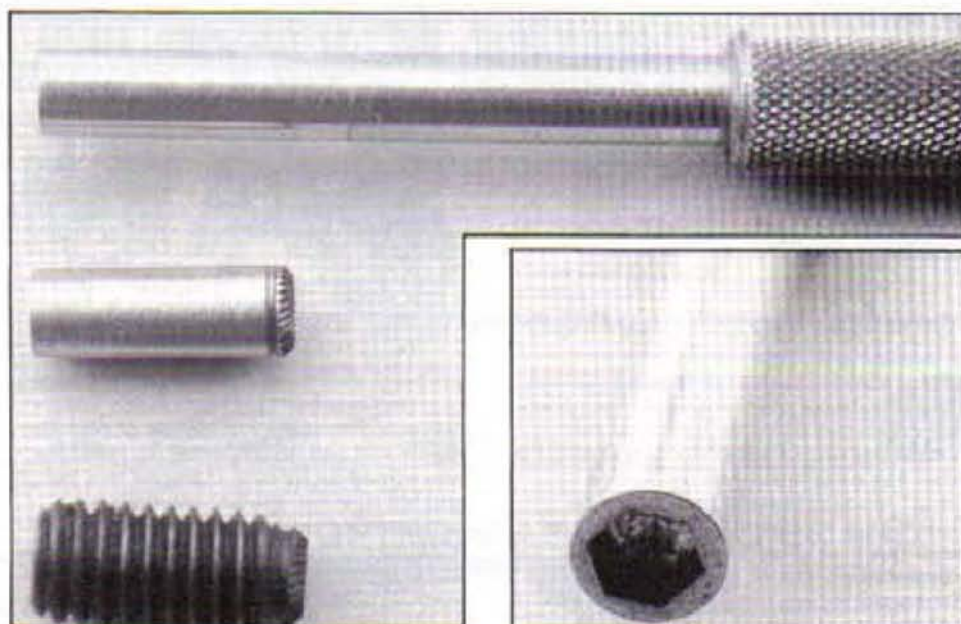


The Knurled handles provide a good grip.

If your own supply of screws differ from these it should still be simple to locate an appropriate size to accommodate the heads. The last column in the list indicates the screws that worked for me.

The length of the bodies will depend, of course, on the reach required, but I have found that about six inches of stock, with the central two inches left full sized and knurled and the ends reduced to leave just enough material around the socket for strength, makes a good general purpose tool. The diameter of the stock will depend on what you have lying around.

The ends of the stock can be simply drilled and tapped for the appropriate socket cap screw, which is then screwed in tightly with a smear of Loctite or similar. Where it is necessary to use a grub screw it is probably better to turn away the thread and press fit them into a plain hole in the end of the stock. Holding the grub screw for turning is simple, just chuck a piece of hex stock (or a BA bolt) in the three jaw and slip the grub screw on it, holding it in place with a slender rod held in the tailstock drill chuck and brought to bear against the end.



Left: From grubscrew to finished product. Right: Business end of the 1/2 AF spanner.

Screw	Head Size	Required Screw
10 BA	.097 AF	M3 socket cap
8 BA	1/8" AF	1/4" W grubscrew
6 & 7 BA	5/32" AF	3/16" W socket cap
5 BA	3/16" AF	1/4" W socket cap
4 BA	7/32" AF	5/16" W socket cap
2 BA	1/4" AF	1/2" W grubscrew

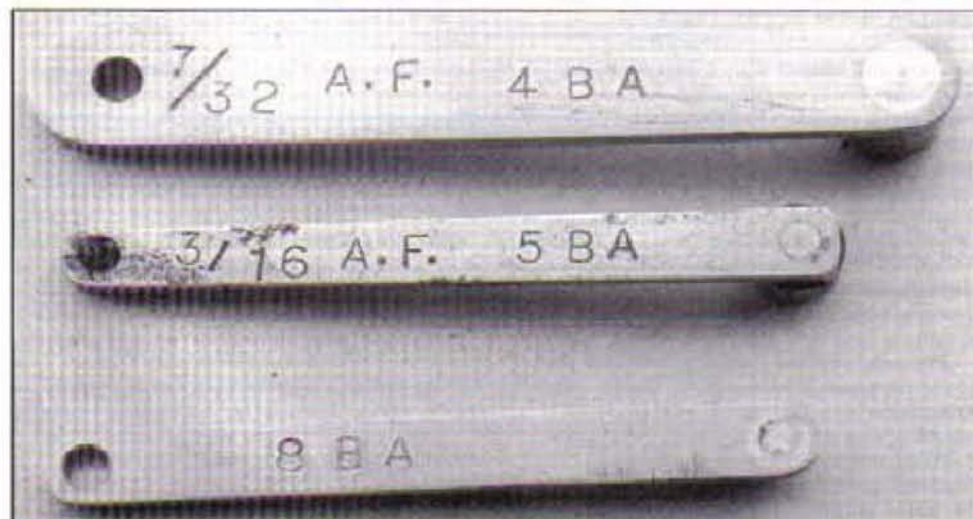
A glance at the chart will show that I have listed a 1/4in Whitworth grubscrew for the 2BA socket. This was the only screw that my supplier carried with a, what I thought would be common, 1/4in AF socket. Even with the thread turned off, this item would be quite bulky when pressed into the rod end. The grubscrew I used was 1in

long, with the socket 1/4in deep. After removing the thread, 1/4in of the end was reduced to .252in and pressed into a 1/4in hole in the shaft. This allowed the shaft diameter to be held to around 3/16in dia. and makes for a much neater tool.

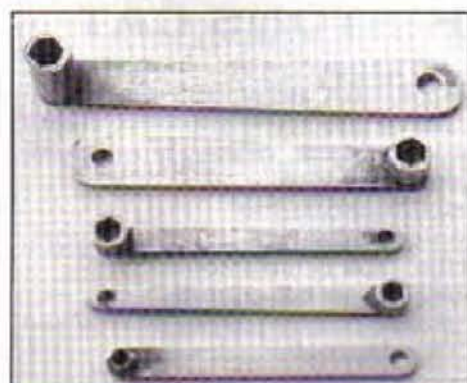
Despite what I said earlier, those without knurling facilities would probably be better off using hex stock for the bodies as the hex portion allows the fingers a better grip than round stock and the turned things don't roll off the bench as readily.

Little need be said about the little box spanners, the photos give the idea. With these, I silver soldered the sockets into the handles but there is no reason why they could not be threaded or pressed in. It is a lot easier to make these using socket cap screws but grubscrews can be used with a little care and planning.

So there you have it. Two evenings work should produce a full set of both the box and long reach spanners and any 'specials', ie. extra long versions, can be made as needed. Good luck with them and remember, next time someone admires them, they are probably wondering how the Dickens they were made. Take a couple of minutes to explain the secret and another budding model engineer somewhere will be able to add a further item to his or her 'box of tricks'.



Backs of the spanners marked with their sizes; note the silver soldered construction.



The author's original box spanner; construction is self-evident in this illustration.

Postscript

The following list will enable readers to identify the required screw for a given spanner size, Ed.

		Socket		Available on	
Size	Dimension	Set Screw	Cap Screw		
met	imp	mm	inch		
3	—	3.00	0.118	M6	M4
—	1/8	3.17	0.125	1/8 BSW/F, UNC/F 0BA	1/8 BSW, 8UNC/F, 3BA
—	3/32	3.96	0.156	3/32 BSF/W, UNC/F	3/32 BSW/F, 10/12UNC/F, 1/2 BA
4	—	4.00	0.157	M8	M5
—	1/16	4.76	0.187	1/16 BSF/W, UNC/F	1/16 BSF/W, UNC/F 0BA
5	—	5.00	0.197	M10	M6
—	3/32	5.56	0.219	3/32 BSF/W, UNC/F	3/32 BSF/W, UNC/F
6	—	6.00	0.236	M12	M8
—	1/4	6.35	0.250	1/4 BSF/W, UNC/F	—
—	5/16	7.94	0.312	—	5/16 BSF/W, UNC/F

FURTHER COMMENTS ON BELT SANDERS

Interesting observations in this extract from a letter by Brian Taylor.

For some reason best known to British manufacturers, belt-sander machines are of two basic designs. One has vertical belt with a horizontal worktable, the other has a flat horizontal belt with a "stop" fence to prevent the workpiece finishing up "O'erYon!" Some horizontal machines also sport a sanding disc with an adjustable worktable, even stand-alone disc machines are available; we had a 24 inch version, way back in my pattern shop days.

During weeks of intensive training in the Dutch modelshop, I gained hands-on familiarity with a German sanding machine in which a workpiece rested on a sturdy horizontal table, perpendicular to which a belt traversed from left to right across a vertical wall. At a stroke, the German design eliminated the pitfalls of horizontal, vertical and disc machines and at the same time retained - even enhanced - their attributes.

Like both vertical and disc machines, a work table bore the weight of a work piece leaving both hands free to manoeuvre it against the belt with a force appropriate to the amount of material to be removed. But where a vertically moving belt is relatively narrow in the left to right direction and a disc removes progressively less material towards the centre (and is unsafe to use beyond the centre), the wall machine in question presented a usable belt-face measuring in the region of four feet from left to right with about six inches exposed above the table.

A search for a similar machine for our UK workshop drew a blank. Improvisation seems a better option than blowing our budget on the cost of shipping a continental machine.

Aware that belt pulleys are crowned to retain a belt in a centralised position, it was reasonable to assume that the drum of our small, British made, flat bed horizontal belt

sander would be similarly crowned. After checking that ball race mountings prevented endwise movement of both the motor and drum shafts, the machine was turned on its side, clamped to a bench and left running, the belt traversing between two vertical drums. Exactly as anticipated, there was no tendency for the 4 x 18 inch belt to wander from its normal tracking position. A makeshift worktable positioned in front of the belt clinched matters; the improvement was so obvious we decided there and then to make a wall machine.

A browse through a local scrap yard revealed a rusty old horizontal sander with two smashed drums and a wrecked stand, but its cast iron belt-plate about four foot long and six inches wide was intact, as were the bearings, drum shafts and 'V' belt drive pulley - ideal for a conversion job. Its 1 H.P., 3 ph motor was undamaged, so we bought that, the scrap sander being thrown in for good measure! If memory is to be relied on, it cost us £10 in 1956.

Stripped from its smashed stand, cleaned and rebuilt with 4 inch diameter wooden drums, we mounted it on a substantial wooden frame with the belt plate and drums set in a vertical plane, a 23 inch wide wooden worktable projected from the belt face for the full four foot length of the machine and continued round the non-driving drum to provide a useful "bobbin-sander" feature. An adjustable-angle, vertical wooden fence-plate allowed items to be squared or angled to fine limits at will.

The machine ran for the full fifteen years of the company's existence and apart from routine servicing, cleaning and belt renewal, required no attention whatsoever.

When circular items such as discs required sanding to size, any contact with the fence tended to interfere with the smooth rotation of the workpiece. In such

cases, the work was presented to the belt at a point clear of the fence; a position calling for a firm grip, otherwise the item was prone to being catapulted "Wi t' others, somewhere o'er yon!"

But, when we had to produce a large quantity of 1/8 inch thick Darvic (ie. PVC) discs in a multitude of diameters without a blemish on either face, a goodly dose of lateral thinking turned the snag to our advantage.

When a rough-sawn disc is supported on a horizontal table and pressed into contact with the sideways-moving belt, the disc behaves like a friction driven wheel and tends to rotate at a hell-uv-a-speed.

The urge to rotate progressively reduces to zero when the platform supporting the disc is swung from the horizontal to the vertical-fence position.

Experiments revealed that a point is reached where the tilt angle provides an ideal combination of abrasive slip and friction drive to ensure that in addition to stock removal, a self-generated slow rotation takes place, easily controlled by finger pressure.

In the manner of a lathe cross slide, a variable-tilt table was arranged to move bodily towards the belt by screw adjustment. It carried a much modified deep throated C clamp device, both jaws of which were fitted with turntables made from mongrelised thrust races taken from scrapped bicycle handle-bar mountings. Both were so arranged that when clamped onto a rough sawn disc, it was still free to rotate. In use, a rough disc was clamped reasonably concentrically between the jaws and fed towards the belt by the cross-slide feed screw. Initially rotation was applied by hand to smooth away high spots, after which the disc rotated by friction gradually reducing in diameter as the feed advanced.

Once the technique was mastered, the production of blemish free discs in diameters ranging from 1 1/2 to 12 inches or more became child's play and was adopted as a recognised production technique.

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